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THE TEACHING OF SEXUAL HYGIENE: MATTER AND METHODS.[1]

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The teaching of sexual hygiene must begin in early childhood, and its importance as a part of education should never be lost sight of by parents or teachers until the individual is well launched in the adolescent period. By the end of puberty, the fifteenth year in girls, and the seventeenth year in boys, the youth should possess sufficient knowledge on sexual matters to protect him not only from the vices that are so likely to become habitual during these years, but also from making mistakes in the case of the sexual system, which might lead to the undermining of the general health.

The development of the sexual equipment and function, and the knowledge of the same, has a double bearing upon development and training of the mind. In the first place, a knowledge of the function of reproduction and a proper attitude of mind regarding it must be recognized by educators to be a necessary part of the equipment of young persons for life. In the second place, parents and teachers are morally bound to treat all questions of sex in the same, simple, straightforward, truthful way that other life problems are treated. In this way only may we expect that a proper mental attitude toward reproduction can be cultivated.

GENERAL CONSIDERATIONS.

Responsibility for the proper instruction of youth in all matters regarding sexual development and the care of the sexual apparatus, together with the great social problem of sexual right living, must in the nature of the case, rest upon the shoulders of the parents.

[1]This article by Professor Hall gives the method by which he has attained success in teaching sex hygiene by the one-lecture plan. However, he points out that the teaching of the lessons of sex hygiene should begin early and continue through the danger period. He recognizes the ideal character of the biological method in the presentation of facts.—ED.

However, parents, as a matter of fact, are as a rule not discharging this responsibility. Statistics gathered from a number of representative colleges in the middle states show that only one young man in twenty receives from his parents any adequate instruction on these subjects before leaving home. If such young men, representing such homes, go out into the world uninstructed to grope their way in the darkness of ignorance, what must be the mental condition of the youth from less thrifty families?

This condition of widespread ignorance regarding some of the most fundamentally important questions of social life and individual development came gradually to be understood among educators and professional men and women, and finally a representative body of educators, physicians, clergymen, lawyers, and social workers met in New York City four years ago and organized a Society of Social and Moral Prophylaxis, whose object as indicated in the name of the Society was by the dissemination of information to protect the individual and the body social against the dissemination not only of physical disease, which wrecks both, but of those low ideals and vicious customs which make the highest life impossible.

Segregation.

The most important lesson learned during several years of experience in presenting this subject to all kinds of audiences is the importance of segregation. By this I mean that boy hearers should be separated from men hearers. Mothers should be segregated from fathers. Furthermore, mothers and daughters should be addressed in separate audiences.

The more homogeneous the audience, the more definite and positive may the statements of the speaker be. It is easy to see that in an address to a mixed audience of parents and children, sex problems would have to be discussed in a general and indefinite way. The circumlocutions would be so veiled and the allusions so remote that the speaker would probably be only vaguely understood by the more intelligent and experienced of his audience; while he would probably be grossly misunderstood by the less intelligent and experienced. Let such an audience be segregated along sex lines, namely, the women and girls in one audience, and the men and boys in another. The situation would be somewhat relieved, though not by any means wholly corrected. One can talk more freely to a group of boys when they are alone

and get more free and frank response from them when he has them alone than he can in the presence of the fathers. The same thing would be true, of course, in an audience of mothers and daughters. Similarly, one would discuss with an audience of fathers certain subjects which boys in the early years of adolescence should not know; such problems as those that concern the ethics of the home, for instance, between husband and wife, problems of maternity and paternity, problems involving the social evils and prostitution. All such matters may be discussed freely and frankly with an audience of men, but, manifestly, youths below the age of seventeen or eighteen should not be present in the audience.

Concerning a division of the audience on age lines, the sexes being mixed, audiences of the parents and then audiences of young people—actual experience makes it clear to me that a public speaker, particularly a physician, can talk more freely to an audience of mothers than to a mixed audience of mothers and fathers. Before such an audience of mothers the problems of maternity, paternity, adolescence of the son and daughter, the mother's relation to adolescent youth, even reference to venereal diseases against which the mother should guard her younger children through instruction in the use of public utensils, and against which she should warn her adolescent daughter—all these subjects may be discussed freely before an audience of mothers, women teachers and social workers, by a physician. But before a mixed audience of fathers and mothers he instinctively begins to deal in glittering generalities that may mean much or little and that are easily misunderstood.

As to the teaching of the story of life to young people in mixed high school or college classes, there seems to be some difference of opinion among social workers as to how that should proceed. There are in the country a few experienced high school and college teachers of biology, who beginning with the lower animals in their life history and life processes, discuss freely, among other things, reproduction in these lower forms, beginning with the protozoa and passing up step by step to the higher animals until finally reproduction among the mammals is freely discussed as to its biological and physiological relations.

That these teachers ever carry the subject so far as to discuss with their pupils the problem of human sex life, I doubt. However, the student of biology who has followed the subject as far as indicated above, would readily infer a very large part of the application of the general principles to the human subject.

An attempt to present even the biology of reproduction to a mixed audience of young people in a single address would be in a high degree unwise. As a rule, then, to which there can be few and rare exceptions, the problems of sex should be discussed in homogeneous audiences where one sex and age is segregated from another.

The Matter to be Presented.

Having divided the hearers into homogeneous groups, what shall be presented to each group? Manifestly, the parents are interested in the far broader field and capable of understanding a far greater range of facts than are the children.

A group of boys of ten to fourteen should be told only those things that boys of that age need to know: for example, questions regarding reproduction: What goes on in an egg during incubation? What has the rooster to do in the process? Where do babies come from? What are general steps of their development within the body of the mother? Why do they begin to develop within the body of the mother? What has the father to do with this process? Then there are questions of physical development in the boy. To many boys these questions do not occur, but they should have them brought to their attention. They should be told how every boy passes through stages in his development in which he assumes gradually the stature, the mental qualities and the functions of manhood. It should be made clear to the boys that, to a large degree, they have it in their hands whether this development shall be a normal one, leading to stalwart virile manhood, or an abnormal one aborted by vicious habits.

A group of older boys, fourteen to seventeen, may be given another chapter in the story of reproduction. Boys of that age are beginning to experience the "Primordial urge" or sexual desire. Many boys of fourteen come to believe that all natural desires should be gratified, but the teacher of sexual hygiene must explain to the youths that the fires of passion must be banked, in order that the energies of manhood may be conserved to a time when they may be put to their legitimate use, namely, the begetting of healthy offspring after the establishment of the home.

A matter of the greatest importance for youths of this group to understand is the influence of internal secretions from the sexual glands upon the body and its development. Most youths have seen the influence of castration upon the development of a young

male animal. This profound effect is due to the loss of the sexual glands which produce internal secretion, distributed with the blood to muscle and nervous system. Without this secretion the animal never develops those splendid physical and temperamental qualities typical of the male of his species.

The matter to be presented to the girls, young women and mothers, is parallel and analogous to that presented to similar audiences of boys, youths and men.

Method of Presentation.

How shall this carefully selected matter be presented to the carefully segregated and homogeneous groups? This is a problem of pedagogy. In my presentation of this matter to boys I have used three different methods: the biological, the moral and the "heroic."

The biological method was not a success because I was able to meet the group but once and no adequate biological presentation can be made in one meeting of a class or audience. Several, or better yet, many such meetings should follow in regular succession, where actual living material collected from the plant and animal kingdoms should be presented and studied with the aid of the equipment of a biological laboratory. Manifestly such a presentation is out of the question for social workers, physical directors, and public lecturers. While this must be conceded to be the ideal method of presenting the subject of reproduction and sexual life, it is a method feasible only for the teacher of biology of a high school or college. A physician could, of course, with the facilities of his office, teach a group of boys or of girls, using this biological method, but the physician can rarely devote the time required for such a course of study.

The moral method was used after I satisfied myself that the biological method could not be used in the short space of one hour. By the moral method, I refer to an appeal, from a moral standpoint, for right living. After several attempts to stir up boys to a high and noble desire for right living, putting my arguments strictly on a moral basis, I came to the conclusion that the method was not effective, that it did not really stir the boys, and that it would not produce the desired effect.

The heroic method succeeded, because it was based on the human instinct of hero worship. Heroes appeal to boys. When one begins to discuss the real hero, every boy in the audience is awake and alert. He believes in heroes. He hopes to be one.

He knows a few, and they inspire him to do and to dare. When one gets hold of an audience through discussing with them some great heroes, he has their undivided, almost painful attention when he asks the question: "What is the secret of the hero's success?" "What is the secret of manhood?" and "What can a boy do to grow into the highest type of husky manhood, which alone makes possible heroic deed?" The lecturer can answer these questions in the last five minutes of a forty-five minutes' talk, and leave every boy in his audience convinced and determined.

As to the method of presenting these matters to young people and parents, I am convinced that incomparably the most effective method is a frank presentation of the findings of science. Don't try to point too many morals. If the presentation has been clear and convincing, the listeners will very readily draw their own conclusions and formulate their own morals.

PHYSIOLOGY AND HYGIENE IN OUR ELEMENTARY SCHOOLS.[1]

By Edgar F. Van Buskirk,
Commercial High School, Brooklyn, N. Y.

Introduction.

The necessity of teaching physiology and hygiene properly in our elementary schools has been vividly brought home to the writer in a variety of ways. As a college student he discovered that some of his fellow students, although they had mastered difficult subjects, did not know many of the essential facts regarding the care of the body. As a teacher in the elementary schools he became especially interested in teaching physiology and hygiene. Boys, who are old enough to learn the "three R's" and some other common branches, are old enough to be taught that disease germs live in sewage, and that therefore it is not safe to wade in such filth. This specific instance is taken because the author happened to see six or eight barelegged boys ten or twelve years old wading in sewage that was being pumped up into the gutter. A few such sights tend to set one thinking and helped to influence the writer to make a personal investigation of the teaching of physiology and hygiene in our elementary schools.

[1] The attention of the reader is called to the interesting distinction made in Mr. Van Buskirk's paper between child interest and adult interest.—Ed.

This investigation was carried on at Teachers College, Columbia, and involved an examination of forty text-books, a dozen reference books and seventy-three curricula of city and country schools widely distributed throughout the United States. The conclusions and inferences drawn from this study group themselves under four heads: the amount of time given, the subject matter taught, the method of presentation and a historical survey.

Time.

As a result of compulsory legislation the subject is very generally prescribed. It is impossible from examination of the curricula alone to determine the exact amount of time given, but where a definite amount is prescribed it is very small. It would appear that the public, only partially recognizing the importance of the subject, has not yet demanded that it be given the attention it deserves.

Subject-Matter.

Upon taking up the second part of the study—subject-matter—an attempt was made to determine the relative importance given to hygiene as opposed to physiology and anatomy and also to inquire whether the principles involved in the study were practically applied.

Nine out of thirty curricula gave physiology and anatomy a preëminent position; seven laid the greatest amount of emphasis upon hygiene; the remaining fourteen apparently attached an equal importance to both subjects. The position taken by Hough and Sedgewick is that "anatomy should be restricted to the minimum amount necessary to give a clear conception to the general structure of the body." Most of the text-books examined gave the names of many of the bones, and such words as "pericardium," "encephalon," etc., were not at all uncommon. A practical application of the study in the form of a consideration of the heating, lighting and ventilation of schoolrooms was prescribed in nearly half the curricula.

Method.

The difficulty of attempting to discover the method used in teaching physiology and hygiene from an examination of curricula is evident, but certain general inferences can be drawn.

Dr. John Dewey of Columbia University states that there are two general methods of teaching and he styles them the "adult" and the "child" method. Without entering into a philosophical and pedagogical discussion, is it not true that the adult in study-

ing this subject would naturally begin with the framework, organs, covering of the body, etc.—anatomy—which would lead to a study of the functions and uses of the various parts—physiology; taking up lastly a consideration of what is beneficial and what is harmful to the body—hygiene; and that in presenting the subject to the child exactly the reverse order should obtain? The child is interested in his sensations and experiences. Therefore with him hygiene is first. Later he will ask, "How? Why? What?" Then physiology and a little anatomy may be introduced. Have we not in this study been violating a fundamental pedagogical truth, namely, to lead the child by gradual steps from the known to the unknown; and have we not been forcing upon him the adult's logical point of view, attempting to present the subject somewhat after the order in which medical students study it? It is true that a majority of the curricula have a well-worked out system, but it hardly conforms to our modern ideas of teaching. These books have overemphasized certain evils and other evils, i. e., those attendant upon overfeeding and neglect of the teeth, etc., have been sadly overlooked. In teaching the evils following the use of tobacco and alcohol one excellent school expert says, "Teach the truth. It's bad enough."

Only twenty-five per cent of the courses of study furnish a list of reference books for teachers, and only half state the aim of the subject. Teachers have been attempting to present a subject of which they know little or nothing, and consequently these important truths have been presented, if presented at all, in a haphazard manner. One often hears teachers remark, "Children have a natural aversion to physiology and hygiene." The children receive blame for a lack of interest due to faulty methods of instruction. Teachers must learn to present the subject in a way to arouse the interest of their pupils. They should be required to take a course in the subject in preparation for their teaching career.

Historical Survey.

A comparison of present with former conditions is encouraging and affords many reasons for hopefulness.

At the present time physiology and hygiene is prescribed to be taught on an average during six or seven of the eight elementary school years. Forty years ago it was taught during only one school year; thirty years ago, in two; twenty years ago, in three; and ten years ago in five.

Hygiene is constantly receiving more attention, and concerning the method of presenting the subject much progress has been made. A few years ago it was an unsystematized subject conducted without the aid of text-books or reference books.

RECAPITULATION.

During the course of this investigation the following facts and inferences have been noted:

First, a study of the time element leads to the inference that physiology and hygiene does not have the important place in the elementary school curriculum that the public apparently desires it to hold.

Second, regarding subject-matter, it is found: 1. Too much time is devoted to anatomy. 2. Hygiene might well receive more attention. 3. The practical phase of the work deserves more recognition.

Third, the following inferences relative to method are made: 1. A presentation of the subject from the child's point of view is not frequent. 2. Though text-books are generally used, few are satisfactory. 3. Reference books for teachers are suggested in only a few curricula. 4. The aim of practical hygiene, "a healthier, happier and more useful life," is not given much prominence.

In conclusion, it must be evident to all that a fundamental knowledge of hygiene is essential for our welfare as individuals, as communities and as a nation. Legislatures and committees working hand in hand with societies and individuals, have improved conditions. The real remedy, however, will not primarily be found in laws, but in education, and education not so much of those whose habits of life have been formed, as of boys and girls.

THE LOUISVILLE AND NASHVILLE RAILWAY PLANTATIONS.

BY JOHN P. BROWN,
Carney, Alabama.

The Louisville & Nashville Ry. Co. has planted some twenty groves along the line of road, in Illinois, Indiana, Kentucky, Tennessee and Alabama, one grove consisting of one million trees on one thousand acres of land. These have made excellent growth and give promise of an early and profitable return for

their investment. The company contemplates the purchase of a larger tract of land on which to make a more extensive timber plantation.

The malicious, jealous and evil-minded opposition which the government authorities have made to the catalpa, has demoralized and discouraged the railways so that they do not know what to do and most of the companies, through the advice of the former forester of the United States, have lost interest in timber planting.

CATALPA TREES SUITABLE FOR LUMBER.

THE CATALPA AS A HARDWOOD TREE.

My first efforts to interest the world in the catalpa were directed to the railways and principally for the production of crossties, but I have never lost sight of the more extensive and important use, for the manufacture of hardwood lumber, for furniture,

agricultural implements, interior finish for buildings, for bent wood, and railway passenger cars, for all of which the wood has proved its superiority.

The general impression among hardwood people has been that the wood was soft, which depends upon the variety of the catalpa and mode of growth.

Catalpa bignonoides of the South is soft. When the trees have passed their mature stage and begin to deteriorate, the wood is soft, although still durable, but young growths with their characteristic vigor are firm, elastic and should be classed with the hardwood.

Can any gentleman define what the term hardwood comprises? In the tropics we have lignum vitae, rosewood, and innumerable species of trees which are such slow growth and have such density that a microscope is required to determine the age. Such trees have grown for more than one thousand years, and it will take another thousand years to reproduce them.

Hardwood is a comparative term. Hickory, oak, walnut, etc., all differ in density and firmness. And you will find by using some edge tool upon the catalpa that it is truly a hardwood.

That it is a handsome wood, suited for fine furniture no one can deny after seeing the samples which I have exhibited.

The oak which we "quarter saw" is no more beautiful, or durable, yet it will take 200 years to reproduce the oak tree which we are now cutting. Black walnut is not the superior of catalpa in any particular, yet the large fine trees which make our best lumber are two hundred to six hundred years old.

Count the annual rings of a large hickory tree, only to find that several generations will pass away while this tree is being reproduced.

The cypress, while not a hardwood, strictly, has taken six hundred years to grow to a diameter of four feet. .

Can any gentleman name one other tree of our forests which he would be willing to plant as an economical and profitable investment?

Yet in twenty years the *Catalpa speciosa* will grow into a profitable size for commercial hardwood lumber.

I have fine furniture in my home made from the trees of sixteen years' growth. All the wood of the catalpa is heart wood; there is practically no sap.

AN INEXPENSIVE ANEMOMETER.

By Frank H. Wade,
Lewis Institute, Chicago, Ill.

In many schools the science of meteorology is severely handicapped by the lack of scientific instruments necessary to make the proper measurements and observations. The anemometer is generally one of these, and the following is intended to show how, at a small cost, a good instrument of the kind can be made and calibrated so as to give reliable results.

There are various kinds of apparatus designed for measuring the velocity of the wind, but the instrument most extensively used, and in fact about the only one the experienced person will

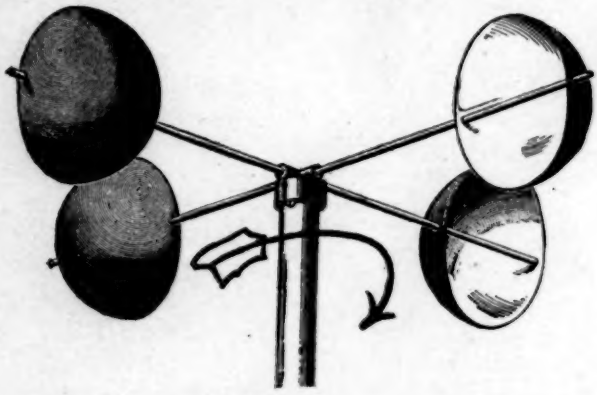

Fig. 1.

give much confidence, is the Robinson Cup Anemometer. This instrument was one of the first designs, and depends for its operation on the effect of the different velocities of air currents on a rotating vane. A reference to the sketch will show this vane to be a cross arm fitted at the ends with half spherical cups, and provided with a pivot to allow rotation in a horizontal plane. The cups are all placed the same way around and as the effect of the wind is greater on one side than the other, there will be rotation, as shown by the sketch, in the direction of the arrow. It can be seen that this rotation is always the same way regardless of the direction of the wind, and since the difference in the effect of the wind on the opposite sides of the instrument is small, the speed of the vanes will be relatively slow. The most important feature of the instrument is, however, the fact that the speed of the vane and the velocity of the wind are exactly

proportional throughout a wide range, as from a light breeze to a gale.

It is not a difficult job to make such an anemometer. The price of the cheapest instrument of this kind on the market is about $14, yet it will be no better, and even not worth as much to the student as the hand-made affair. The spherical cups can be obtained at most architectural ornament stores, or at a cornice-maker's shop, for five cents each, and the other materials can be filched from some scrap heap, or bought at any hardware store. An instrument which is giving satisfaction at the Lewis Institute was made of the following dimensions:

Cups 4 inches in diameter.[1]

Length of arm, 1 foot.

The other dimensions are unimportant and were according to the sketch, which may be followed or not as is most convenient.

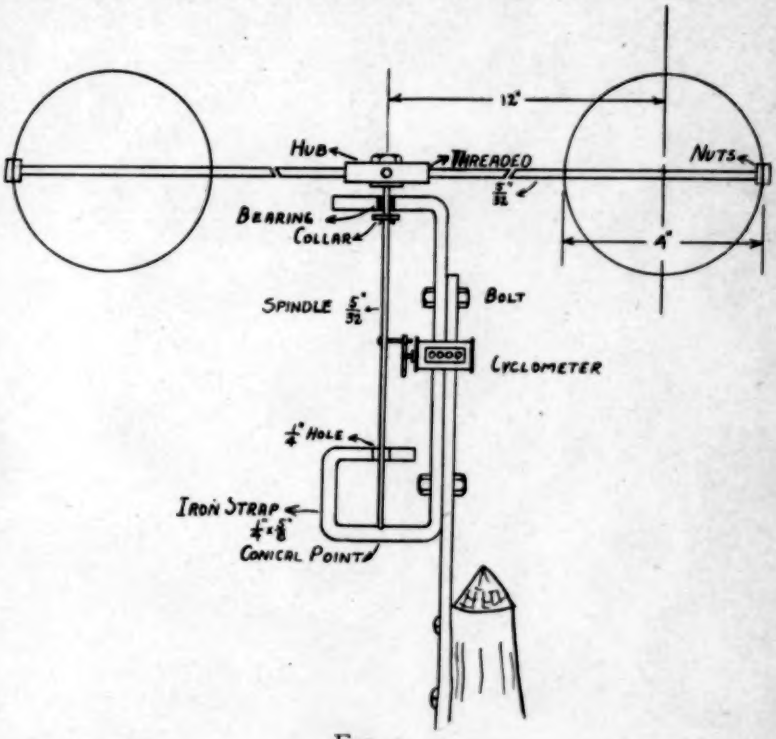

FIG. 2.

The main features to be provided for are: the point of the spindle A marked "conical point" which should be hardened; the

[1]Purchased of the Friedley-Voshardt Co., Chicago, Ill.

collar, which is to prevent the apparatus from lifting out and blowing away; and the brass bushing, or other soft metal bearing above collar to reduce wear. The cups should be fastened on the arms securely, as shown.

After the instrument is made, the next thing to do is to calibrate it, that is, translate its readings from revolutions per minute of the vanes, into miles per hour of the wind. To do this we find the number of feet of wind that must pass in order to revolve the vane once. This number is a constant, being independent of the velocity of the wind. It may be found in three ways: (1) by formula, which will not be accurate; (2) by a comparison with some standard instrument; and (3) by a direct test. A direct test can be made by taking the instrument in hand and running a measured distance, keeping track of the number of revolutions. In the case of the instrument described above, the results of a number of tests gave 17.6 ft. of wind passed for each turn of the vane. Hence one turn per minute equals a velocity of 17.6 ft. per minute, or 0.2 miles per hour. This number may be called the constant of the instrument, and in order to get the velocity of the wind, we count the number of revolutions in a minute, and multiply by 0.2, or the number of revolutions counted in twelve seconds will be the number of miles per hour of the wind.

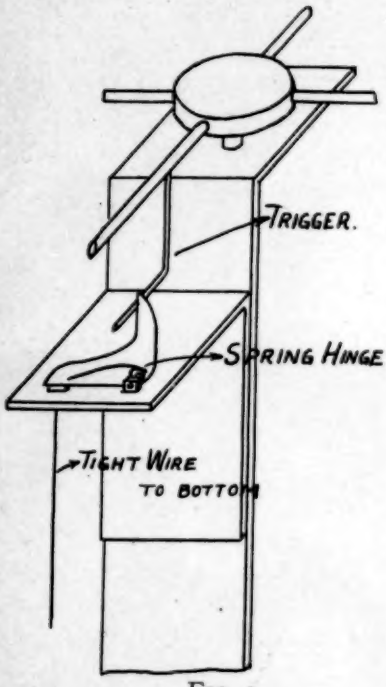

FIG. 3.

But to try to count the revolutions when the instrument is up on a pole going at a high rate of speed will prove rather embarrassing, and the best way to do is to attach a common bicycle cyclometer to the spindle of the vane. This can be read at quite a respectable distance with almost any telescope or field glass. Another way is to have a spindle arranged to operate an electric contact which in turn "clicks" a telegraph sounder or telephone receiver. Still another way, which brings in the principle of the

old-fashioned telephone, is to have the spindle operate a trigger which hits on the end of a tight wire stretched to the bottom of the pole. The sketch shows how this may be done. Sound can be transmitted in this way for surprisingly long distances. There are other ways by which the speed of the vanes may be found, but these three will probably fit any ordinary case.

The study of the weather is very entertaining when we have the aid of a few simple instruments like the above. The wind-vane, the rain-gauge, the barometer, in fact all the instruments needed by the amateur weather-man can be made around the house, and the interest excited in the student by the scientific use of instruments he has made himself, is as real as it is valuable.

A METHOD OF FINDING THE MERIDIAN BY SHADOWS, AND MECHANICALLY GRADUATING A SUN-DIAL.

By Edison Pettit,
State Normal School, Peru, Neb.

In all laboratory exercises in astronomy it is difficult to bring accuracy and simplicity together. Especially is this true in the two valuable exercises of establishing a meridian by shadows and of mechanically graduating a sun-dial. The methods here outlined are believed to accomplish this.

I. Establishing the Meridian.

At any time in the morning the sun will have a given altitude and make a certain angle with the meridian. At some time in the afternoon it will again have the same altitude, and will then make the same angle with the meridian, but on the other side of it.

Now whenever the sun has the same altitude in the sky, the shadow of a body cast on a level surface is always the same length; and, conversely, when the shadow is the same length the sun has the same altitude in the sky as before. Applying these principles we proceed as follows:

In a south window, level a table WZ, Fig. 1, and over the south edge hang a plumb line AB, having a bead C (a small shot split and mashed about the plumb line) attached so that it shall be a few inches above the table. Mark the position D of the shadow of the bead at any time in the morning, and with the point B (where the plumb bob touches the table) as a center and

BD as a radius draw the arc MN. In the afternoon watch till the bead's shadow again touches this arc and mark its position E. The shadow is now the same length as it was in the morning at D, and by the above principles the sun has the same altitude and the meridian is the bisector of the angle EBD. Draw EB, and BD, and bisect this angle. (For this it is necessary only to draw two arcs of equal radii, whose centers are at D and E and to connect their point of intersection with B.)

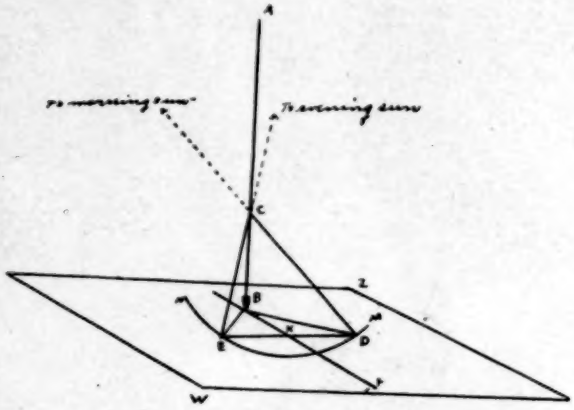

FIG. 1.

This line BF is the meridian, and if the work has been carefully done a high degree of accuracy may be attained.

II. GRADUATING THE SUN-DIAL.

For this purpose we require the construction of a simple piece of apparatus.

Divide a paper circle into twenty-four parts, and each of these parts into four parts as shown in Fig. 2. (It will be found convenient to have the circle about 3 inches in diameter.) Draw the diameter of the circle through one of the first divisions and number the divisions as shown in the figure. Glue this circle to one of the same size made of thin wood. Through the center of this circle pass a straight wire about a foot long. Support the wire perpendicular to the circle. To do this a block, B, may be

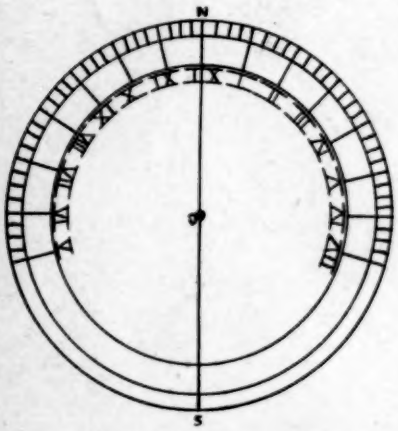

FIG. 2.

glued to the back of the circle M and a hole a little smaller than the wire bored through it, as shown in the upper position of Fig. 3; then when the wire is inserted it will be held fast by its own friction. If a more permanent apparatus is desired, it may be constructed as shown in the lower figure.

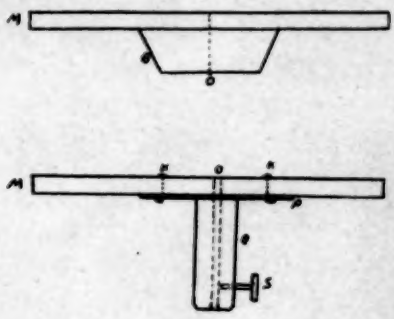

FIG. 3.

Solder a battery connector C to a metal plate (tin or sheet brass) P, and attach this to the back of the circle C by means of two brads KK driven through from the graduated side of the circle and clinched tight on the metal plate. The thumb nut S may be used to adjust the circle on the rod, which passes through the hole O.

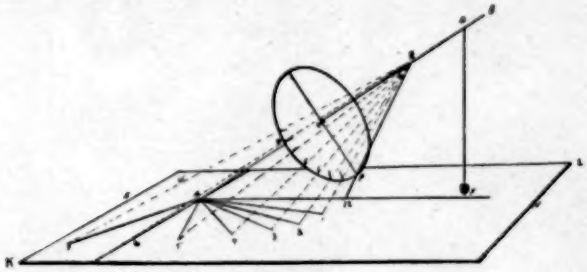

FIG. 4.

On the paper or other surface to be graduated, KL, Fig. 4, draw a straight line NS down the midle to represent the meridian. Near one end of the line at A erect a perpendicular A6, to represent the six hour line. Place a sharpened end of the wire BA, so that it will make an angle BAN with the board equal to the latitude of the place for which the dial is being constructed, and likewise be in the plane of the meridian NS.

To adjust the wire at the proper angle and direction, level the board KL, and suspend a plumb line DF from the wire AB and move the wire so that the bob shall hang over the meridian NS, then set AB at the proper angle with a protractor. When this is done the wire should be held firmly in place by means of a laboratory support placed at some point near the end B of the wire. Now tie a thread on the wire at some convenient point as E which should be near the end B, and stretch it fairly tight to the meridian, just touching the circle C as at P.

Bring the XII mark on the circle to coincide with the thread. Then bring the thread to the 6 hour line at 6, and it should touch the circle at the VI hour mark H. If it does not the position of the axis must be changed to one side so that it will. When the circle is properly adjusted the thread will touch the VI hour mark on the circle when held on the 6 hour line, and the XII hour mark when held to the meridian and the angle BAF will be equal to the latitude of the place. Now bring the thread into coincidence with each of the other graduations on the circle and each time mark the place, 1, 2, 3, etc., where it strikes the paper, KL, together with a number corresponding with the number on the circle. For places in the United States it will be only necessary to graduate the dial for hours between 5 A. M. and 7 P. M.

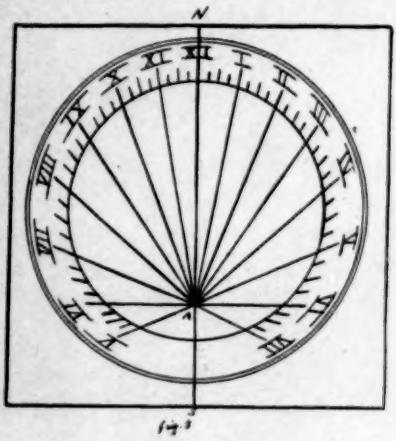

FIG. 5.

Finally, connect all the points so found with the point A, and extend the lines to the edge of the paper. The graduations may be finished off as shown in Fig. 5. Now remove the circle from the wire, and drive the wire in at the point A, being careful to have it in the same position it was throughout the process, that is to say, making an angle with the dial equal to the latitude of the place and pointing in the direction of the meridian line.

If a vertical dial is desired the process of graduation is exactly the same except that the angle between the board and the wire must be equal to the complement of the latitude of the place throughout the process, and it is only necessary to graduate the dial for hours from 6 A. M. to 6 P. M. for any latitude.

When the dial is complete it is only necessary to set it so that the meridian mark is in the meridian of the place. If it be a horizontal dial it must be level, if a vertical dial it must stand in the plane of the prime vertical, as on the south wall of a building with the graduations down. When properly set up the shadow of the wire on the graduations will mark the apparent solar time, from which, by knowing the longitude and the equation of time, the standard time may be found.

THE ELECTRICAL CONSTITUTION OF MATTER.[1]

By E. Waite Elder,
East Side High School, Denver, Colorado.

In the teaching of even elementary science, we must teach the truth and nothing but the truth, although we may not hope to be able to teach the whole truth. The teacher must therefore be in possession of so much of the truth as will enable him to avoid error and to present such measure of it as his pupils can grasp, in a way within their comprehension. It goes without saying that science can be taught only by one whose knowledge extends far beyond the text-book which the class is using. I feel justified, therefore, in presenting to you to-day some of the facts gained by those explorers along the confines of physical science, who have in recent years opened up a new world hitherto as little known as was the world of electricity before the genius of Faraday illumined it.

The effort of philosophy in all time has been to reduce the inextricable confusion of the material universe to a simple uniformity; to find in all the multiplicity of phenomena a basis of "oneness"; "to reduce a differentiated heterogeneity to an undifferentiated homogeneity."

Physics recognizes three entities as making up the material universe; matter, energy and ether. Matter is that which occupies space and has weight or mass. Energy is the power to change the state of rest or motion of a body, and exists in many forms. The ether is the vehicle of energy from one portion of matter to another, and came to be postulated in order to explain the transmission of light and other electrical and magnetic disturbances. More will be said concerning its properties later. Matter and energy are within the range of our everyday experiences; but ether is more "ethereal." "In order to reach oneness we must assume, either that these are but forms of an underlying reality, or that they are themselves one in some mysterious way altogether beyond the power of human reason to grasp."[2]

I shall not try to give a history of the work done in radioactivity nor the processes by which the facts and conclusions have been reached; but shall only attempt a summary of results, and the bearing which these results may have on the problem of

[1] Read before the Science Section of the Colorado Teachers' Association.

[2] "The New Knowledge," by Robert Kennedy Duncan. I wish to acknowledge my indebtedness to this work for many of the facts given in this paper.—*Author.*

the "oneness of the universe." I may say in passing, that the *balance* was the first great instrument of precision in scientific investigation, with its ability to weigh to a millionth of an ounce. The *spectroscope* is a million times as sensitive as the balance. The *electroscope*, which is the instrument used in the investigations in radio-activity, is a million times as sensitive as the spectroscope—can, in fact, be used to count the individual units of which atoms are made up.

Twenty-five or thirty years ago, William Crooke, in his study of the discharge of electricity through highly exhausted tubes, discovered what he called a fourth state of matter, radiant matter—solid, liquid, gaseous and radiant matter. Some fifteen years later, J. J. Thompson, in a similar study, discovered some peculiar things about this "state of matter." When an electrical discharge takes place in a highly rarefied gas, there is an actual transmission of particles of matter from the positive pole to the negative pole. This is shown by the fact that a small vane, similar to that in a radiometer, will be set turning, if in the path of these particles; and a small piece of platinum will be heated to redness, if similarly placed. Curiously, these particles are always alike, no matter what kind of gas is in the tube or what kind of material is used for the electrodes. They travel with great velocity and can be deflected by a magnet. Their mass is about one thousandth that of a hydrogen atom. These particles are called electrons or corpuscles. It has been found that they may be produced in other ways than by the discharge of electricity, as in burning gases, glowing metals and from metals on, which ultra violet light falls.

Further study of corpuscles from any of these sources shows them to be in every case negatively electrified particles, having the same charge as a hydrogen atom and traveling with a velocity of from 10,000 to 90,000 miles per second. They have the power of discharging electrified bodies; they give rise to X-rays in bodies on which they fall; and they are absorbed by all bodies in direct proportion to the densities of those bodies.

In addition to these negative particles or corpuscles, positive ions have been found which carry positive charges of electricity of about the same size as those carried by an ordinary atom. They have much slower velocities than the corpuscles, their mass is a thousand times as great and they are scarcely at all deflected even in a very strong magnetic field.

The wonderfully fruitful study of radio-activity grew out of the discovery of the Roentgen rays about sixteen years ago. Radio-activity may be defined as the process by which matter gives off minutely small particles and comparatively enormous amounts of energy involving an intra-atomic rearrangement of the ultimate units out of which matter is built up. Radio-active substances are those in which this process is most marked—most marked because most violent. Radium, polonium and actinium, newly discovered elements, and the associated elements, uranium and thorium, which have been known to the chemist for a generation or more, are the most prominent of these substances. We shall confine our discussion to radium, since the others differ from it only in degree.

Radium is known only in its compounds, chiefly the chloride and bromide. Its radio-activity consists in the giving off of rays called Becquerel rays, which possess the power of passing through ordinary matter. This penetrating power is independent of the kind of matter, but depends only on its density. If they fall on a sheet of lead, they are stopped by it as readily as by a sheet of iron once and a half as thick, or by a sheet of aluminium four and a half times as thick. Zinc and tin, having nearly the same density, offer about the same opposition to their passage. They produce phosphorescence and chemical action, are capable of discharging an electrified body and may be bent by a magnet. A further examination of these rays shows that they are not all alike, but are of three distinct kinds: Rays that have very little power of penetrating bodies and are only slightly bent by a strong magnetic force. These are called alpha rays. Rays that have very great penetrating power and are easily bent by a magnetic force, but in a direction opposite to the alpha rays. These are called beta rays. Rays that are not bent by the strongest magnetic force, but have enormous penetrating power. These are called gamma rays.

The alpha rays are positive ions, charged hydrogen or helium atoms (probably the latter), expelled from radio-active substances with a velocity of 20,000 miles per second. (It is the bombardment of zinc sulphide by these ions that produces the phosphorescence in the spinthariscope.)

The beta rays are nothing more nor less than the negatively charged corpuscles which we have seen are produced by the electrical discharge in rarefied gases. They are shot out of the

radium atom with an enormous velocity which often approximates that of light, 186,000 miles per second.

The gamma rays are not matter, but are some kind of waves in the ether, set up by the beta rays or corpuscles. These ether waves are probably similar to light waves and "wireless" waves, but of different wave length.

In addition to these rays, radium gives off another "something" of a very different character, called an emanation. This emanation is given off continuously, as indeed are also the rays, and acts like a gas. If a current of air is passed over the radium, the emanation is carried along with it, and if this air is passed into a vessel surrounded by liquid air, the emanation is condensed to a liquid at —150 degrees Centigrade. It is inert like argon. It exists in the air everywhere over the land but in infinitesimal proportions. In the open air there are about 1,500 ions per c. c. As each c. c. of air contains forty millions of millions of millions of molecules, it is not to be wondered that radium emanation in the air escapes the chemist. It is given off in enormously larger quantities when the radium is dissolved in water. It cannot be destroyed by any agency of man, but undergoes spontaneous decomposition into helium with the evolution of an immense amount of heat.

The most energetic chemical action known is the burning of oxygen and hydrogen. One liter of a mixture of oxygen and hydrogen when exploded evolves enough heat to raise the temperature of a liter of water about two degrees C. A liter of radium emanation would evolve in the process of its spontaneous decomposition about three million times as much energy, or enough to raise the temperature of sixty tons of water from the freezing to the boiling point. Even this is only a small portion of the total intra-atomic energy stored up in matter. The total energy stored up within the atom in hydrogen is so great that if we could release the whole of it, as much heat would be evolved from one gram as in the burning of five tons of coal. Fortunately this energy is fast bound by the corpuscles. If at any time a small fraction were to get free, the earth would explode into a gaseous nebula.[3] The presence of a few grams of radio-active substances in each cubic mile of the earth's crust would account for all the heat of the earth.

Radium emanation in water decays into neon: in copper sul-

[3] J. J. Thompson.

phate solution into argon. Water in the presence of radium decomposes into hydrogen and oxygen, but there is too much hydrogen evolved, sometimes as much as ten per cent to twenty per cent too much. Here we have the actual transmutation of matter: but note that it is spontaneous and can be neither produced nor prevented by any power of man. (The reported transmutation of copper into lithium by Ramsey a year or two ago has been proven false by recent more careful experiments by Madam Curie.)

Although the production of the emanation by radium is continuous, it is exceedingly slow. A gram of radium in radio-active equilibrium produces about 0.46 mm.^{3} of helium per day, that is, about a cubic centimeter in six years. Becquerel has calculated that one sq. cm. of radio-active surface would radiate into space 1 gram of matter in 1,000 million years.

Now what bearing have these facts on a theory of the "Electrical Constitution of Matter?" As shown by Mendeleeff's table of the elements, the atoms of all the elements are so curiously related to one another that any hope of explaining the mystery apparently inherent in them lies in the finding of particles smaller than the atoms out of which they could be built up. We have such particles, a thousand times smaller than the smallest atom, in the corpuscles emitted by all bodies under the influence of electrical discharges in vacuo, and by radium at all times. *These little bodies are invariably associated with matter and arise from matter—from any form of matter under special conditions, and from special forms of matter under all conditions. From whatever source they arise, these corpuscles are similar in all respects, with the exception of mere velocity.* A study of these facts impels us to believe that the atoms of all elements are built up of these corpuscles, the difference in the elements being due to the difference in the number of corpuscles in the atom and to their grouping.

Sir William Thompson has said that if a drop of water were magnified to the size of the earth, the molecules of which it is made up would be in size somewhere between a baseball and a football. A molecule is made up of two to one hundred atoms. Sir Oliver Lodge says, if we imagine an ordinary church to be an atom of hydrogen, the corpuscles constituting it will be represented by about a thousand grains of sand, each the size of a period, dashing in all directions inside, or rotating with inconceivable velocity, and filling the whole interior of the church with their tumultuous motion.

It is to be recalled that the beta rays given out by radium consist of these corpuscles, and that they are negatively electrified. Since a negative charge of electricity has always associated with it an equal positive charge, we would expect our corpuscle to have associated with it a positively charged particle such as we find in the alpha rays. Our atom then becomes a collection of positive ions and negative corpuscles arranged in groups which are more or less stable, their stability depending on the velocity of the constituent corpuscles. J. J. Thompson has worked out mathematically the arrangements of these groups and his results have been experimentally verified by the use of magnets. He has shown that with a certain number of constituent units there will be a certain grouping which will be stable. As units are added, the grouping will become more unstable until, with the addition of a given number of units, a new grouping takes place which in turn is stable. This new grouping with recurring stability shows a periodicity corresponding in a way with the periodicity of the elements as indicated in Mendeleeff's table.

The mass of the atom must be the sum of the masses of its constituent units, and the atomic weight will be a measure of the number of these units and therefore of the complexity of the atoms. It would follow that the elements of highest atomic weight would have the most complex atoms, the atoms most likely to be disturbed by anything which would interfere with their stability. We find that radio-activity, then, is the result of the rearrangement of the grouping in a very complex atom, the particular configuration of any atom depending upon the velocity of the corpuscles and ions of which it is made up. When this velocity falls below a certain critical value, a new grouping takes place with the evolution of an amount of energy which breaks down the atom. For example, the radium atom consists of somewhere around 225,000 corpuscles and ions, moving with certain velocities in certain definite configurations, these configurations depending on the velocities of the constituent corpuscles. Any loss of energy from this group results in a slowing down of the corpuscles. When these velocities decrease to a certain point, the particular grouping can no longer be maintained and the atom breaks up into scores of helium atoms, the odd corpuscles and ions going off at the same time as alpha and beta rays.

We have said that the corpuscle *has* a charge of negative electricity. Suppose we say that it *is* a negative electrical charge, or the unit of negative electricity. There is much evidence in

support of this proposition, as also that there is a definite unit of positive electricity. Our atom then becomes a collection of positive and negative units of electricity, and the forces which hold the atoms and molecules together, the forces which exhibit themselves in the various properties of matter, have their origin in electrical forces exerted by positive and negative units of electricity aranged in groups of different kinds.

Inertia is the one sole unalterable property of matter and is the measure of the mass of a body. It can be shown mathematically that the mass of a body, as measured by its inertia, varies with its velocity; that if its velocity approximates that of light its whole mass can be accounted for by its velocity. In dealing with corpuscles, these mathematical results can be experimentally verified. As a result of the close correspondence of the values obtained by mathematical calculations with those gotten by experimental determinations, we are justified in saying that the mass of a corpuscle is due entirely to the electrical charge. But this is another way of saying that its mass is the mass of the bound ether carried along by the charge, just as the mass of air carried by a rapidly moving bullet varies with its velocity.

This leads us to say a word with reference to the ether. As we said, it is the sole vehicle for the transmission of light and other electrical and magnetic disturbances. These disturbances travel with very great velocity, therefore the ether must be very elastic. They are transverse, hence the ether is a solid. The density of the ether carried along by the corpuscles is about 2,000 million times that of lead. It must either be stupendously compressible or else this represents its density everywhere.

What then is the conclusion of the whole matter? An electrical charge, whether positive or negative, is a point of stress in the ether. This stress differentiates an exceedingly small part of the ether from all the rest surrounding it and constitutes the corpuscle. A thousand of these corpuscles, arranged in a particular way, make up an atom of hydrogen; 200,000, one of mercury, etc. A group of these atoms, from two to a hundred or even several hundred, make up a molecule, and countless multitudes of molecules constitute a body like the earth, the sun or our own bodies. Matter is in its last analysis identical with electricity, and electricity is a special state of the ether. We have reduced the physical universe to ether and energy. Can we go farther?

ADAPTATION OF THE COURSE IN PHYSICS TO THE NEEDS OF GIRLS.[1]

By W. G. Whitman,
State Normal School, Salem, Mass.

Does not our experience show the futility of adapting all pupils to our one course in physics? Is it not more reasonable to look for better results if we adapt the physics we teach to our pupils? The idea that a pupil who has no aptitude and no liking for a particular subject, and who has no special need of it, should be compelled to take that subject to remedy his deficiency, is losing ground.

Broad changes in our educational policy are under way. We are committed to the idea of specialization; to adapting the subjects taught to the pupils' serious desire. In our schools there are different courses of study. In one city there may exist schools where different types of work are given: for example we have manual training, technical, trade, business, art and Latin schools. These schools recognize the different needs of different groups of pupils. Each school emphasizes one kind of training without eliminating all the others. They treat the subjects in a way to have a bearing upon the future occupation of the individual student. This separation of pupils into groups for special kinds of work is evidence of our belief in giving the pupil the kind of work which is thought best suited to his needs. It is not revolutionary then to apply the same principle to physics teaching. Within reasonable limits separate the pupils and select those portions of the subject for each group which can best be used by them.

As far as the studying of physics for its cultural value is concerned, it might be treated in much the same way for both boys and girls. Both would need the same general treatment for the broad understanding of natural forces without which a person would seem unduly ignorant. But when we consider those parts of physics which are to be of special interest and profit to the pupil, there the work divides.

The majority of the girls will eventually find their way to take charge of the home. Our modern home is complex with its numerous scientific appliances. The girl cannot begin too early to prepare for her responsibilities. Among her problems will be,

[1] Abstract of paper given at meeting of New York State Science Teachers' Association at Syracuse, December, 1909.

how to manage the household economically without sacrificing health. Involved in this problem are many questions of physics. The study of properly selected portions of physics will give her much valuable information and will guide her in proper methods of investigation. We must frame our course for the greater number of girls who present themselves. In a course for girls then we should give a broad treatment touching the whole field, though in some parts rather lightly; we must emphasize those portions which have direct bearing or application in the household.

The majority of the boys will go into business or mercantile work. They will at some time give all their time to acquiring proficiency in their chosen field, but in the high school they will be giving only partial time to the special preparation for it. Business and mercantile work are to-day interwoven with industrial work. Industrial work depends largely upon mechanical devices. The subject of mechanics should be given much emphasis as preparation of the boys for their chosen lifework. As comparatively few of the boys go to college it is essential that they get a good foundation in the principles and practical applications common in the business world, while they are in school.

It is not natural that a girl should have a very great interest in the details of mechanics; she does not expect to use special knowledge of machines much in the future and she is not in touch with mechanical devices at the time of studying physics. It is true that a teacher can work up interest in these topics among certain girls, but with the average girl this would be unnatural stimulation and not desirable.

I believe thoroughly in teaching some mechanics to girls. But I do not think it wise to go as deep into mechanics with girls as I would with a class of boys. Not that it would be too difficult, nor because of mathematics, but because it takes time to extend the subject, and there is a much richer field of study for girls in the subject of heat. There is much, also, in sound, light and electricity which should be included in a course for girls.

There must be life and human interest in a course in physics for girls. It must be awake to progress in the direction of their special interest. For example in considering the question of gas supply used in the home, show how it has developed that the purpose for which gas is used has changed. Formerly gas was used for its illuminating power almost wholly; now, since the

advent of the gas range, people buy more gas for heating purposes than for illumination. Much of the lighting done is also due to the heating effect of the gas, as is the case where mantles are used.

The important thing to know about gas to-day is how much heat it will give rather than how much light. The question of establishing a heat standard in New York is at present before the authorities. Now is the time to bring this question before the physics class; especially is this interesting to a class of girls. They may follow the progress made and see how a standard for determining the quality of gas is obtained. They may consider whether the heat standard would have an advantage over the present photometric standard, both from the point of view of the consumer and of the producer.

One object which I have in mind when teaching physics is to put the pupil into such close touch with his environment that he will see in the commonplace things more than so much dead matter; I would vitalize matter; make an object commonly seen tell the observer some story. Let me illustrate by reference to the way I try to make thermometer mean more than "something which tells temperature." In a demonstration lecture on the subject "temperature," the idea is emphasized by suitable illustrations that temperature and amount of heat are two different things. Question the value of knowing temperatures. Pupils will suggest many cases where it is important to know temperatures. Discuss temperature of human body, variations in this; temperature and health; cold and warm blooded animals. Extremes of temperature on surface of the earth; increase in interior and decrease as ascend above the earth. Temperature of moon, sun, space. Extremes of temperature reached artificially, for what purposes. Possible ways of measuring temperatures; historical development of temperature measuring instruments. The common thermometers. Method of making a mercury thermometer. One double period is given to the pupils to start making a mercury thermometer. In previous work they have had some experience in blowing bulbs in glass tubing. With the thermometer tubing, it is more difficult and I do not expect many thermometers will be made. With good luck a girl will get a bulb blown, filled with mercury and perhaps the tube sealed. Possibly one may even get the boiling and freezing points marked. Four-fifths of the class will not get the tube filled and sealed. I tell them if they wish they may finish it by putting in extra

time. Some of them will not be interested enough to do extra work upon it while others will ask if they may come after school to finish it. But whether they finish it or not they will have a different mental attitude toward thermometers. They know the industrial history of the thermometer. In my class this year a girl made a thermometer, marked the scale and mounted it in two hours' time. I showed the completed thermometer to the class of boys who are preparing for college. Thermometer making is not in their course. On their own initiative I had one-third of the boys in the laboratory that afternoon after school trying to make a thermometer. The interest created in this way is natural and wholesome and I believe there is just as valuable laboratory practice in it for high school pupils as there is in "Finding the Error in the Fixed Points of a Mercury Thermometer" or the "Coefficient of Cubical Expansion of a Gas at Constant Pressure."

I wish to suggest a number of experiments in heat which I am using with a class of girls:

1. Conductivity of materials: Sand, air, iron, cotton, straw, paper, asbestos and sawdust are tested.

2. Absorption and Radiation of Heat: (a) Absorption; two thermometer, the bulb of one painted dull black, are placed at same distance from some heat supply. (b) Radiation; two calorimeters, one painted a dull black, the other bright and polished, are filled with hot water; note fall in temperature at regular intervals.

3. Convection: (a) in liquids; (b) in gases.

4. Ventilation: Test air currents in room. Test purity of air by the carbon dioxide determination.

5. Combustion of Fuels: Wood, coal, oil, alcohols. Test products, carbon dioxide, water and carbon monoxide when combustion is incomplete owing to a limited air supply.

6. The Bunsen Burner.

7. A Study of the Gas Stove (Bunsen Type). (a) As a cooker; (b) as a heater; (c) as combined heater and cooker.

8. A Study of the Kerosene Stove (a) as a cooker; (b) as a heater.

9. A Study of the Alcohol Stove (a) as a cooker; (b) as a heater.

Compare the results of 7, 8 and 9 considering efficiency, cost and the changes they effect upon the air of the room.

10. A Study of the Electric Stove. (Work with this stove is postponed until the subject of electricity is undertaken.)

11. Testing the Accuracy of the Gas Meter. Practice in Meter Reading.

12. Cost of Cooking Various Dishes on the Gas Range. Relative cost when cooking large or small amounts.

13. Testing an Alcohol-heated Flatiron.

14. Comparative Tests with Denatured Alcohol, Wood Alcohol and Ethyl Alcohol as Fuel for the Chafing Dish.

15. Making a Fireless Cooker and Testing its Efficiency; (a) as a Cooker; (b) as a Refrigerator or Cold Box. In selecting non-conducting material, make use of information found in exp. 1 on Conductivity.

16. Cooling through Change of State.

17. Heat of Fusion of Ice.

18. To Determine the Melting Point of: (a) Paraffin; (b) Butter; (c) Lard; (d) Olive Oil.

19. Freezing Mixtures.

20. Tests Made on a Refrigerator, Temperature, Ice Consumption and Heat Absorbed.

21. Effect of Evaporation upon Temperature.

22. Temperature Change Resulting from Expansion and Compression of a Gas. Production of a Fog by Sudden Expansion of Moist Air.

23. Dew Point and Relative Humidity.

24. Pasteurization of Milk; Test Acidity of Milk: (a) when fresh.

(b) Unpasteurized and kept at room temperature for two days.

(c) Unpasteurized and kept in the refrigerator for two days.

(d) Pasteurized and kept at room temperature for two days.

(e) Pasteurized and kept in refrigerator for two days.

25. Flash Point and Burning Point (Fire Test) of kerosene, lard and alcohol.

26. Relation of Boiling Point to Pressure: (a) increasing pressure; (b) decrease in pressure.

27. The Boiling Point of Alcohol.

28. Fractional Distillation: Separate Alcohol from Water.

29. The Use of Volatile Inflammable Liquids.

Much of the work in this girls' course is related to domestic science. Where domestic science is taught in the school, each department should supplement the work of the other.

WHAT THE STUDENT SHOULD GAIN BY LABORATORY WORK IN PHYSICS.[1]

By Alice H. Bruere,

Wadleigh High School, New York.

It may be safely stated, I think, that every experienced teacher of physics will admit that the justification for the place given to physics in a high school course, and the time devoted to it, are due both to the fact that an acquaintance with the fundamental laws and principles of the science are of almost vital importance to the individual at the present day, and to an even greater degree, perhaps, to its adaptability to the process of education.

Properly adjusted and conducted laboratory work can and ought to contribute important assistance in both phases for which the subject is taught.

Many in the teaching profession feel that laboratory work has failed in the past to accomplish results that were commensurate with the time and energy expended upon it, and that more would be gained by diverting the time so used, at least in part, to lecture or recitation work. Frankly, I think it true that our laboratory work has not accomplished all that it should, but I believe its failure to do so is due, not to the inadequacy of laboratory work as a means, but rather to the kind of work we have attempted there, and the gauge we have set for it.

In the early enthusiasm for science by the laboratory method, discovery and determination of the laws by accurate measurements, were the keynote for the work in physics. This was expected of children who had no training in nicety of manipulation, no experience which could lead them to detect where causes of error might be looked for, and the characteristic of whose age is the desire for the result, the fact, rather than patience that a result may be obtained. The consequence for the average student, in the hands of all but exceptional instructors, was, therefore, discouragement, failure, or a result obtained by the timely intervention of the instructor. Dissatisfaction with this process led many teachers to adopt a plan in which the pupil mechanically went through certain motions with apparatus previously carefully adjusted for him, read certain numbers, placed them in

[1]Read before the New York Physics Club, October 11, 1909.

a table, the outline of which was prepared, and then drew the carefully indicated conclusion. Both these methods were the outcome of attempts to meet the aim in physics which was prescribed by the university. The student must come at facts by experiments, but the all-important factor in the pursuit of work was the acquisition of the subject.

Please let me state emphatically that I consider the subject itself of great importance, and that I wish never to lose sight of that fact in any work, but I believe the other phase of teaching, i. e., education, demands more attention than it has received.

Do we sufficiently consider the students, their environment, their background of acquired knowledge and experience, and adapt our work in physics to these conditions and to the end of the greatest development of the pupil mentally and morally?

In the average school of to-day, the selection of exercises and the method of procedure are chiefly controlled by their fitness for establishing a law. Permit me to enumerate a few points which I believe should have a controlling influence when we arrange laboratory work, which would lend it vitality, and make for satisfactory results. I shall, I am conscious, merely reiterate statements of points, all of which have frequently been presented, but a repetition may instigate us to once more consider this work with a view to passing judgment on what we are doing.

Laboratory work ought:

1. To develop interest and enthusiasm by adding reality through the individual study of phenomena at close range.

2. To supplement the demonstration and lecture work so that the understanding of the subject matter may be more complete through individual verification of laws.

I will present some concrete examples to demonstrate how, in my opinion, this may be brought about.

Every boy or girl is interested in the fact that the pull of a horse, or the push of the piston, need not measure as much as the weight of the load when it is on an incline, and that the pull decreases in proportion as the steepness grows less. They will measure load and effort with this fact in mind with interest, though comparatively little interest may be evinced when we approach the problem with the purpose of obtaining numbers by which the law of the inclined plane may be established. When the measurements have been made, they may still be used to derive a general statement or law.

In the same way they are glad to know why a barge loaded with coal, or an ironclad vessel does not sink, and what conditions would cause it to sink. Arrange apparatus that conditions may be similar to those in the instances cited, and the principle of flotation will acquire a meaning.

Students know that it takes time for a sound to travel from one point to another at some distance, for they are familiar with the echo, but it is a pleasant addition to know that they can measure the velocity with which it travels and that in such measurement approximately the same result is attained by using forks of very different vibration rates. Incidentally they also learn that the velocity for sounds of different wave lengths is the same, when they travel through the same medium and when all other conditions are the same.

They like to compare the time it takes for a definite weight of water to reach the boiling point with the time it takes the same weight to boil away, or change to steam; to find why the image in a plane mirror is erect and that in a pond, which is also a plane mirror, is inverted; or why images are sometimes enlarged and sometimes diminished when formed by the same lenses. Emphasize the ***reasons,*** let the measurements be the accompaniment. When they have grasped the reason in a definite case, and have from this been led to the generalization, they will more easily apply the law to another phenomenon. Boys and girls would rather know an explanation of that which has already entered into their experience, than go afield to add new abstract facts, but when a relation has been established, the interest is carried over to this more comprehensive truth.

Vital interest is always awakened when pupils realize that an electric current can be used to make a magnet, and a magnetic field to produce an electric current, but never to the same extent as when they experience the pleasure of themselves using the apparatus to produce these phenomena. This interest also tends to impress the facts and conditions upon which they depend.

I believe it is this desire for conviction by experience as well as curiosity that causes the crowds of those who wish to "try on" the new invention at an exhibition or exposition. Could we not among us devise at least thirty-five experiments that are in this way definitely related to matters with which the student has some acquaintance, and make them acceptable to the Board of Regents as well? Very likely some exercises

already in use fulfill these conditions; others would need only adjustment.

Handling and adjusting apparatus, however crude or simple the arrangement, will give the pupil a quicker perception of the arrangement of apparatus placed before him in a demonstration; it will, therefore, make it easier to transfer his attention from the objects to the phenomenon.

I do not believe, however, that his limited experience in an elementary laboratory ought to be expected to make him a skilled manipulator; it can make him more intelligent about things that pertain to the laboratory and their use.

When the students perform experiments, let us remember that they have neither hands nor apparatus of which a great degree of accuracy may be expected, but under all circumstances let us insist upon that attention to detail and accuracy in arrangement and measurements which *is* possible. Watch the manipulation of the student; let him know he is being observed; give help, by instruction and demonstration, which will avoid difficulties he is not himself ready to avoid through the experience in earlier work, but insist that he shall do the manipulation. He likes the laboratory hour better for it in the end, has gained some training for eye and hand, has exercised his judgment, and will have extended his comprehension.

Let us emphasize the fact that failure to attain results is due to failure in establishing the conditions, that he is dealing with cause and effect that are invariable, and that every repetition must be accompanied by a close scrutiny of the arrangement and a more thoughtful, careful manipulation of the apparatus. Implicitly there will be established an appreciation of work that is done in a scientific manner, and a scientific fact will grow to mean thought, care, conviction. The pupil will recognize the value of painstaking.

In which training are our young people most deficient—in skill to attain an end or in living up to principle? Shall we not merge some part of our effort to teach physics into an effort to educate men and women who shall be better citizens for having spent some hours in our classes?

PHYSICS TEACHING IN HIGH SCHOOLS.[1]

By Superintendent Darwin L. Bardwell,
New York City.

What I have to say upon the teaching of physics in high schools will fall into three divisions: 1st, the pupils; 2nd, the teachers; 3rd, the tools.

Obviously the most important division of this subject is that which concerns the pupils: the schools are maintained for the benefit of the pupils; the teachers are there to serve the pupils; and the subjects in the course of study, text-books, apparatus, equipment, are all for the benefit of the pupils. That which must always be kept in mind, therefore, is the greatest good of the pupils.

There seems to be a somewhat common impression that the girls are as a rule less proficient in physics than are boys. For thirteen years I was a class room teacher of physics, during which time my classes were almost invariably mixed classes. In all of this time I was never able to discover that it is safe to make any such generalization. There was great difference in the way pupils approached and satisfactorily pursued this subject. This difference, in my judgment, was due less to natural ability than to previous experience for the interpretation of the subject. The point of contact, therefore, must relate to the experience of the pupil.

Some fifteen years ago, when nature study was being advocated very ardently as an important activity of the elementary schools, Cornell University issued from time to time a series of very attractive and helpful nature study leaflets. In an early number of these leaflets appeared a sentence which read, as nearly as I can remember, something like this: "He who thinks chiefly of his subject, teaches science; but he who thinks chiefly of his pupil, teaches nature study." The idea involved in this quotation is of broader application than to the nature study and applies to a wider field than the elementary school. Any person who anywhere, in either the elementary school course or in the high school course, thinks chiefly of his subject, is failing to give his best services. Always and everywhere the supreme object of consideration is, not the subject, but the pupil.

Now let us have a few moments to consider the teacher. Great

[1]Abstract of remarks made at the Annual Dinner of the Physics Club of New York, Friday evening, April 8, 1910.

gains have been made within the past few years in the equipment of the teacher for his task. In many quarters great specialization has been urged on the part of high school teachers. In my judgment, the advocates of this policy have gone too far. I am prepared to say that so far as my observation and experience go, the best high school teacher is not the one who is simply an expert highly specialized in his own field, but rather the one with broader outlook and sympathy. The teacher of physics in the high school who knows physics thoroughly, but nothing else, will not as a rule be as good a teacher as one who, perhaps, knows physics less thoroughly, but who does know something quite clearly and definitely of chemistry and biology. What we need, I think, is not the narrow specialist, but, if I may so express it, the broad specialist. It must not be forgotten that the high school is not the place to train scientists or specialists. Pupils of high school age are not ready for that. It appears, therefore, that the high school teacher of physics is at his best who keeps fresh and alert in the field of human sympathy as well as in the subject of physics. He needs continually to vary and modify his outlines of instruction and his lists of experiments. His revisions may not always be an improvement, considered from an abstract standpoint, but there is an improvement if by each readjustment he attempts to get into more thorough sympathy with his pupils in their varying needs as they come before him year after year. The tendency, quite naturally, is when a good series of experiments has been determined upon, or an excellent outline of work has been made, to consider that these are to be given without further change; but he who does so is rapidly getting into a rut which will certainly result in stagnation. Every teacher constantly feels, I believe, the need of this sort of readjustment, for his own sake as well as for the sake of his pupils. The thing which is new attracts him. He likes a new text-book, and to change from time to time, unless, indeed, he is so unfortunate as to be the author of the text-book he is using. The change of text-books from time to time, bearing in mind necessary economies, is a good thing, even if the new text-book is not as good as the old one. Such changes keep teachers from stagnating. They also help them to keep the pupils in mind, rather than their subject.

Let us now consider briefly the tools; and for convenience I shall think of these as two sorts: 1st, the laboratory, and, 2nd, the text-book.

In turning our attention to the laboratory I would like to inquire for the moment the purpose of individual experiments by pupils. We have long since passed the stage when it is necessary to advocate individual experiments by the pupil—that is now conceded; but it is not out of place to inquire the purpose of these experiments in order that we may understand better their mode of procedure. We are sometimes told the purpose of the experiment on the part of the pupil is to teach him to investigate; but the high school pupil is rarely if ever able to do any investigation worthy of the name. Certainly we do not have individual experiments performed by pupils in any hope that any considerable number of them will even catch the spirit of the investigator. Then we are told that the purpose of the laboratory experiment is to verify laws already demonstrated; but so far as I am aware those laws do not need verifying. In no real sense does the pupil verify them. To verify means to prove the truth of them. That task would be a long and difficult problem of specialization; but what the pupil does need is to have these laws and facts made vivid to him. The purpose of the individual laboratory experiment is neither investigation nor verification, but the making vivid and alive. If this is at all true we need less of long, technical, quantitative experimentation and much more of the short, comparatively easy qualitative experiment. The experiment which is performed with reasonable accuracy, with intelligence, and with inspiration, is one which is not over-technical but in which the pupil easily and intelligently makes the progress toward a desired end, which desired end he has at least partially in mind from the beginning. To spend, say, ninety minutes on a single experiment in finding the specific gravity of a solid is, I believe, a monstrous waste of time. From the above it is evident that in the opening up of the subject in class room work or lecture room, demonstration is essential. This work should keep ahead of the laboratory work, although the latter should not lag far behind.

Just a word as to the text-book. When physics was new in our high school course, the text-books were often scientifically inaccurate, but they were attractive, interesting, and suggestive of most interesting and valuable applications to everyday life. With the development of experimentation, text-books have greatly increased in value in this direction, but have become monstrously lean and ill favored in other directions. They no longer call attention, or even suggest, things which are so interesting to

the pupil in the way of application to everyday business problems. To say that such text-books are no longer available does not answer the argument. If such things are desired and they are not to be had, it is our business to make them. The teachers of this city are able to do anything to which they set their minds. Brief, vivid and suggestive essays, monographs or descriptions, whatever they may be called, should be prepared to supplement and enrich the ordinary text-books and laboratory work. This, I think, is what more than anything else our high school course in physics lacks. If this is done, I am confident that the pupils will take hold of the subject with avidity and increasing interest, not to speak of the greater profit.

THE RELATION OF PROBLEM WORK TO THE NEW PHYSICS MOVEMENT.

By William G. Fuller,
New Paltz Normal.

The return to the "Natural Philosophy" of our fathers in the teaching of physics is hailed with delight by many teachers as the panacea for the ills of present-day instruction in physical science. That there is a decided change soon to come, none can deny. The course has become, in altogether too large a degree, a study of technical details, having little bearing on the actual life of the student. As an illustration, what degree of interest can a teacher hope to arouse in the average high school girl by such experiments as "Breaking Strength of a Wire," "Wheatstone's Bridge," etc.? When students are obliged to perform experiments of this sort, the work is done in a mechanical way, the sole object being to get an acceptance mark as soon as possible, and thus avoid a failing mark at the end of the term. Surely a change is needed, and it is undoubtedly coming.

But before abandoning at once the whole scheme of present-day instruction, let us inquire into the history of the course as now given in the majority of schools, and discover if possible the reasons for the conditions now existing. Undoubtedly the old course in "Natural Philosophy" was one of the most popular given, especially among the boys, and many were the exclamations of astonishment at the wonders wrought by the instructor, and many the enjoyable minutes spent in gazing upon the spectacular experiments. Also the fact that the teacher did the work of preparation aided in making the course popular.

However, as the reports of the best experiments spread among the students, and the same experiments when performed the next year did not meet with the same degree of interest, the teachers began to realize that something was wrong, and attempted to remedy the matter. Since the lecture method of instruction is adapted for mature minds, great difficulty was encountered in holding the attention of the students except by constant surprises. The fact that the students remembered the flash and noise, and forgot what the experiment was intended to convey, tended to stimulate the teachers to find some other way of instruction.

About this time the influence of Agassiz began to be felt in all the sciences, and the need of self-activity on the part of the student, as well as personal contact with the apparatus was realized. This led to the introduction of laboratory experiments for the students, a marked improvement in the method of instruction. The teachers realized more than ever the indefiniteness and the superficiality of the old method, and to further increase the efficiency of the new system, introduced the use of problem work in connection with the experiments. It was soon found that the problems aided greatly in clarifying the pupil's ideas, and in clinching the physical principles involved, and this naturally led to the introduction of still more work of this nature, until at the present date we find the mathematical work predominating, and almost crowding out the other phases of the subject.

A change of the present system is certainly advisable, but lest the pendulum swing too far, and we abandon entirely the use of problem work, in our haste to teach "Natural Philosophy" again, let us consider the value of this branch of our subject. We consider mathematics to be the exact science, and feel that when a student can handle a problem and get a definite result that he has a mastery of the principle that can be obtained in no other way. For illustration, the electrical units have but little meaning to the student until he uses them in concrete problems based on everyday applications of the electric current. The idea of a watt takes on an entirely new meaning when the student learns that a carbon lamp on a 110 volt circuit takes .5 of an ampere, and consequently 55 watts. So too, the student realizes that physics stands for something in the practical life of the world, when he meets a problem of this sort—How many of the carbon lamps mentioned above can be lighted by a 5 H. P. gasoline engine under perfect conditions? Here is something tangible, that even the girls will appreciate, and the gratifying

results that every teacher has obtained from problems of this sort, justifies the conclusion that such work is of value.

In choosing problems, great care must be exercised in selecting, not mathematical puzzles, or those involving a large amount of computation, but simple direct applications of the principles to be taught; always requiring, however, progressive reasoning on the part of the pupil. In successive problems one point after another should be brought out slowly, clearly and in logical order. This progressive idea will surely lead to the firm retention of past principles and to the easy conquest of the new. Such a group is illustrated by the following problems:

1. What current is a carbon lamp absorbing if it has a hot resistance of 220 ohms on a 110 volt circuit?
2. At what rate is it using energy?
3. At 10 cents per K. W. hour, what is the expense of lighting a hall using 50 of these lamps?

This progressive idea will also tend to eliminate one of the greatest sources of waste, the effort of the pupil to solve problems without any idea as to the correct method to employ. I have known pupils to figure for half a period on a problem and be on the wrong track all the time. It must be admitted that when students reach the physics class they should be able to handle figures, so that the mental training must come through the reasoning out of the method. I have found it a great saving of time when taking up new problem work, to state a number of problems, and have the student explain the method of arriving at the result, without actually doing the computation necessary.

That enough science is to be found in the daily life of the students for an excellent course in physics, is not to be doubted for an instant, and many lists of suitable topics have been printed of late. An ideal course might well be based upon the model home of the future, that dustless, germless house, where a push of a button sets all the household operations into full swing, and the servant problem is at last solved. But, in order that affairs may always run smoothly in even this ideal home, the lady in charge must have an understanding and appreciation of the details of the machinery. And if this be true, must we neglect a phase of our instruction that is of supreme value in clinching the fundamental principles, and making clear the technical points, all too vague at a distance?

By all means, let us have a change in the physics course as now given, but let us retain that most valuable part of our work, which at once affords, not only the best kind of training in accuracy, but the greatest development of the reasoning ability, as well.

A METHOD FOR PROJECTING AND BLENDING COLORS.

By F. R. Gorton,
Michigan State Normal College, Ypsilanti.

In the study of color it is often desired to superpose lights of different kinds upon a white screen. Several devices have been designed for this purpose, but they are, as a rule, complicated and expensive. The following method which is submitted is decidedly effective and can be carried out almost without cost, provided an ordinary projection lantern is at hand.

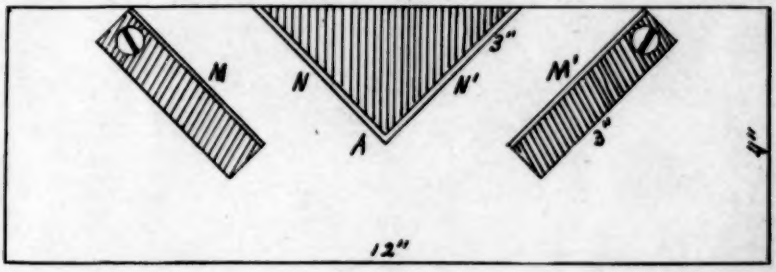

Fig. 1.

Four plane mirrors M, M′, N, and N′, which are 3x2½ inches, are mounted on a wooden base 4x12 inches as shown in Fig. 1. Block A is wedge-shaped, having a right angle at A, and is fastened to the base by means of a screw from below. The blocks to which M and M′ are attached swing with considerable friction about the screws which hold them to the base. All mirrors are set perpendicular to the base. The mirrors may be held in place with rubber bands or suitable clips.

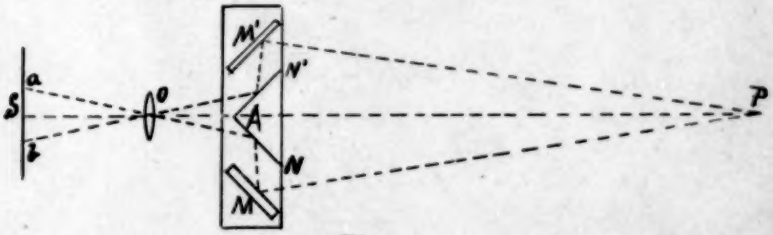

Fig. 2.

The color card is prepared by making two round holes in a piece of cardboard about the size of a lantern slide. These holes should be about one-half inch in diameter and 1¼ inches between centers and in a horizontal line. The holes are now to be covered with films of the colors that it is desired to super-

pose, e. g., yellow and blue. If it is desired that the colors be complementary, the films must be selected by actual test.

Fig. 2 shows the method of setting the blending device before the objective of a lantern in order to superpose the colors which come through the color card placed at *a* and *b* in the slide carrier *s*. When the light from *a* falls upon mirror N it is reflected to M and thence to the screen at P. Similarly, light of the other color from *b* is reflected by the mirrors N′ and M′ to the screen. Now, by the proper adjustment of M and M′ the color spots can be wholly or partially overlapped on the screen at P. If the selection of complementary colors has been well made, the superposed colors will produce white. From a small package of color films offered by apparatus dealers, several pairs of complementary colors can usually be made up.

A modification of the device for work with three colors will be given in another issue of SCHOOL SCIENCE AND MATHEMATICS.

SUSPENDED TRANSFORMATIONS.

BY FREDUS N. PETERS,
Central High School, Kansas City, Mo.

To the student of chemistry one of the most common as well as, at times, one of the most annoying of phenomena, is that of "bumping." Its cause is thoroughly understood, and consequently various methods of entirely preventing or of materially lessening its violence have been devised.

Although this phenomenon is so common and has occasioned so much attention, nevertheless it is possible that not often is it thought of as but an example of a large number of other familiar cases with which it is not associated at all. These may all be classed under the heading, "Suspended Transformations," a term used by Ostwald in a recent book, an American edition of which has been published by Longmans, Green & Co.

It has long been known that water as well as various other liquids may, by extreme caution, be cooled considerably below its point of solidification and kept there without change of state for a greater or less length of time; yet, if the smallest particle of the solid phase of the substance be introduced, instantaneous solidification takes place. Supersaturation is an equally familiar phenomenon, or perhaps it may be called the same in another form. Some organic substances are known which

crystallize from their saturated solutions with such difficulty that without the addition of a minute quantity of the solid phase crystallization often seems almost impossible.

What is true of liquids is equally so of gases. They may be cooled considerably below the temperature at which liquefaction takes place without that change of state following. Experimental proof of this is somewhat difficult owing to the necessity of removing all trace of the liquid phase; but, as Ostwald suggests, it is probably this which accounts for the cloudbursts so destructive in their violence. Large quantities of vapor have been slowly cooled to a temperature considerably below the point of liquefaction without precipitation taking place. A swift current of air or some other means suddenly introduces, it may be, but a minute quantity of the liquid phase, whereupon complete and instantaneous transformation takes place with destructive violence.

The phenomenon of allotropism is another illustration of suspended transformation. All chemistry students are familiar with amorphous or plastic sulphur and with its method of preparation. It is equally well known that sulphur also exists in two general crystallized forms, the rhombic and the monoclinic. The former is obtained directly by the evaporation of a solution of sulphur at room temperature, and is the stable variety of sulphur. But when crystallized from the molten condition it appears in the monoclinic form. However, this latter is unstable, and unless kept above 96 degrees Centigrade it is slowly transformed into the rhombic variety. It is undoubtedly in a condition of suspended transformation.

Amorphous sulphur is likewise a similar case. By the sudden cooling it has been brought into a viscous condition, not differing essentially from what it had at the transition stage between 196 and 260 degrees Centigrade, and there the transformation has stopped. It does not remain there long, however. In a few days the viscosity has disappeared, and a considerable portion has assumed the rhombic variety; yet it is said that months or even years are necessary for the complete transformation into the rhombic.

Likewise, phosphorus exists in two well-known forms, very different in their stability. Both are known to exist at all ordinary temperatures; but in accordance with the law pointed out by Ostwald, the less stable variety appears first; that is, in its preparation from bones or calcium phosphate, the yellow phosphorus is always obtained. At first nearly transparent and but

slightly colored, it soon, especially if exposed to light, becomes covered with a thin coating of the red. Further transformation, however, seems suspended, at least almost entirely so, unless the temperature is raised. If kept at the boiling point of water for some time it becomes very considerably colored, indicating the formation of the stable variety. At 250 degrees Centigrade in an atmosphere containing no oxygen the change is rapid. We see here, therefore, a case in which the transformation has been suspended indefinitely, and yet, possibly, if we could measure it, we should find that it is going on all the time from the less toward the more stable variety.

It is said that in the preparation of oxygen by some methods, possibly by all, a greater or less amount of ozone is produced. Those methods give the most, however, in which little or no heat is needed to secure the generation of the oxygen. May it not be possible, as in the case of phosphorus and sulphur, that the less stable, the allotropic, form is first produced, and that transformation in this case is but slightly suspended; or in methods where higher temperatures are necessary, the transformation is complete within an exceedingly short space of time, so that the quantity of ozone is inappreciable?

If this may be cited as a case of very rapid transformation, on the other hand, as Ostwald suggests, there are some that proceed almost infinitely slow. For example, we are familiar with carbon in three forms: diamond, graphite, and coal. Of these the first is the most stable; there may be slow transformation of our best anthracite into graphite, and of graphite into diamond. But so slow is this that even the most optimistic chemist never expects to arise some morning and find that his coal has been transformed into diamonds.

The subject is one of very great interest and well worth the thought and study of any teacher of chemistry.

A SYSTEM FOR THE PREPARATION OF QUALITATIVE "UNKNOWNS."[1]

By Louis J. Curtman,
College of the City of New York.

The table which is given at the conclusion of this paper is proposed for the use of teachers in qualitative analysis who desire a simple system for the preparation of qualitative unknowns which takes into consideration the quantities of the metals and acid radicals present. The advantages of such a system will be apparent after a brief consideration of the methods generally in use. These are two in number; one consisting in the preparation of a large number of unknown mixtures in fairly large quantities, portions of which with or without dilution are given to students for analysis; the other employs a stock of strong solutions of simple salts from which the unknowns are prepared when needed.

The first method while having the advantages of convenience and rapidity of distribution, has the disadvantage of yielding solutions whose qualitative and quantitative composition must necessarily be fixed. The proportions in which the constituents are present in these solutions are generally unknown. Variation of the relative quantities of the constituents for any given mixture is found impracticable because of the large number of bottles which would be required. In consequence of this, wherever this system is employed, no attempt is systematically made to vary the quantitative proportions of any definite mixture. As this method limits the number of unknowns to that which is possible from a qualitative standpoint only, and as this number is embarrassingly small for some groups, it becomes necessary with large classes to issue the same solution to several students. It is needless to state that this unavoidable result is a serious objection to the method. Moreover there is the danger of the composition of these "fixed" solutions becoming secretly known by students. The evil resulting from this cause is aggravated in consequence of the fact that the instructor, having once settled on the composition of his stock solutions, is prone to prepare them of the same composition from year to year.

The stock solutions of simple salts employed in the second method are usually saturated or strong solutions. The actual

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[1]Presented at the Boston meeting of the American Chemical Soc., Dec., 1909.

Group	Substance	Formula Weight	Solubility of salt in 100 pts. of cold water	Per cent Metal	Quantity of salt be dissolved in 1 liter to give strength 1cc. = 100 mgs of metal
I	$AgNO_3$	170	v. s.[3]	63.5	157
	$HgNO_3.H_2O$	280	sol. in pres. of HNO_3	71.5	140
	$Pb(NO_3)_2$	331	48	62.5	160
	$Pb(C_2H_3O_2)_2.3H_2O$	379	46	54.6	183
II	$Hg(NO_3)_2.\frac{1}{2}(H_2O)$	333	sol. in pres. of HNO_3	60	167
	$HgCl_2$	271	7.4	74	135[4]
	$Bi(NO_3)_3.5H_2O$	484	sol. in pres. of HNO_3	43	233
	$Cu(NO_3)_26H_2O$	295	v. s.	21.5	465
	$CuCl_2.2H_2O$	170	120	37	270
	$CuSO_4.5H_2O$	249	40	25	400
	$Cd(NO_3)_2.4H_2O$	308	v. s.	36	278
	$CdCl_2.2H_2O$	219	140	51	196
	$3CdSO_4.8H_2O$	769	v. s.	43.5	230
	As_2O_3	198	4	75.5	( )[5]
	Na_2HAsO_3	170	v. s.	44	227
	$Na_2HAsO_4.12H_2O$	402	28	18.7	( )[6]
	As_2O_5	230	150	65	153
	$SbCl_3$	226	sol. in pres. of HCl	53	188
	$SnCl_2.2H_2O$	225	v. s.	53	189
	$SnCl_4.5H_2O$	350	v. s.	34	294
	$SnCl_4$	260	v. s.	46	218

[3]Very soluble.
[4]This amount readily dissolves in 1 liter of water containing 50g. of NaCl.
[5]33g. in 1 liter HCl (1—1) gives strength 1cc. = 25 mgs. As.
[6]267g. in 1 liter will give strength 1cc. = 50 mgs. As.

III	$Al_2(SO_4)_3.18H_2O$	666	107	8.1	( )[7]
	$AlCl_3.6H_2O$	242	400	11.1	900
	$Al(NO_3)_3.8H_2O$	261	v. s.	10.3	970
	$Cr_2(SO_4)_3.18H_2O$	716	v. s.	14.6	690
	$K_2Cr_2(SO_4)_4.24H_2O$	1000	20	5.2	( )[8]
	$Cr(NO_3)_3.9H_2O$	400	v. s.	13	770
	$CrCl_3$	158	sol. in pres. trace $CrCl_2$	33	304
	$FeSO_4.7H_2O$	278	60	20	500
	$Fe(NO_3)_3.9H_2O$	404	v. s.	14	715
	$FeCl_3.6H_2O$	270	v. s.	20.7	482
	$Ni(NO_3)_2.6H_2O$	291	50	20	500
	$NiCl_2.6H_2O$	238	v. s.	25	400
	$NiSO_4.7H_2O$	280	106	21	475
	$Co(NO_3)_2.6H_2O$	291	v. s.	20	500
	$CoCl_2.6H_2O$	238	v. s.	24.5	407
	$CoSO_4.7H_2O$	281	50	21	475
	$MnSO_4.4H_2O$	223	123	25	400
	$MnCl_2.4H_2O$	198	150	28	360
	$Mn(NO_3)_2.6H_2O$	287	v. s.	19	527
	$ZnSO_4.7H_2O$	288	135	22.5	445
	$Zn(NO_3)_2.6H_2O$	298	v. s.	22	455
	$ZnCl_2$	136	v. s.	48	208

[7]620g. in 1 liter will give strength 1cc. = 50 mgs. Al.
[8]192g. in 1 liter will give strength 1cc. = 10 mgs. of Cr.

Group	Substance	Formula Weight	Solubility of salt in 100 pts. of cold water	Per cent Metal	Quantity of salt to be dissolved in 1 liter to give strength 1cc. = 100 mgs. of metal
IV	$BaCl_2.2H_2O$	244	41	56	179
	$Ba(C_2H_3O_2)_2.H_2O$	273	63	50	200
	$Sr(NO_3)_2.4H_2O$	284	40	31	324
	$Sr(NO_3)_2$	212	39	41.3	242
	$SrCl_2.6H_2O$	266	106	33	304
	$CaCl_2$	111	v. s.	36	278
	$Ca(NO_3)_2.4H_2O$	236	v. s.	17	590
	$MgSO_4.7H_2O$	246	77	9.7	( )[9]
	$Mg(NO_3)_2.6H_2O$	256.5	200	9.4	1060
	$MgCl_2.6H_2O$	203.5	365	11.9	837
V	NaCl	58	35	40	250
	$Na_2HPO_4.12H_2O$	358	9.3	13	( )[10]
	$NaNO_3$	85	80	27	371
	KCl	75	32	52	192
	$KHSO_4$	136	v. s.	28.5	350
	KNO_3	101	31	39	257
	NH_4Cl	53	33	34	294
	$(NH_4)_2SO_4$	132	76	27.5	365
	NH_4NO_3	80	200	22.5	445
	$(NH_4)_2HPO_4$	132	36.5	27.5	365
	LiCl	42	80	16.7	600
	$LiNO_3$	69	48	10	( )[11]

[9] 515g. in 1 liter will give strength 1cc. = 50mgs. Mg.
[10] 77g. in 1 liter will give strength 1cc. = 10mgs. Na.
[11] 500g. in 1 liter will give strength 1cc. = 50mgs. Li.

quantities of metal or acid radical in these solutions are seldom calculated. For analysis certain of these solutions are mixed usually in no previously determined proportions and in some cases in proportions which experience has shown to give good results; but no precise knowledge of the quantitative composition of the unknown is had. This method, while superior to the first, is objectionable because it results in the preparation of "unknowns" of unknown quantitative proportions. As the mixtures are made up when needed and as these can be varied at will, no permanent "key" is required; further, it is possible to vary the quantitative proportions even though these be unknown.

It appeared to the writer that if the stock solutions of simple salts were made up of known strength and provision made for the delivery of definite volumes of these solutions to students' "unknown" bottles of which the capacity was also known, a precise qualitative and quantitative knowledge of the mixed unknown solutions would be had. The use of saturated stock solutions is unsuitable because owing to differences in solubility, as well as variation in the metallic content of salts, they cannot

all be of uniform concentration. In the system here proposed, the stock solutions are all of uniform concentration except in the few cases marked where because of the small solubility of the salt, the adopted strength could not be obtained; in such cases one-half or one-fourth of the uniform standard was chosen.

The strength that has been found convenient in this laboratory is 1 cc.=100 mgs. of metal, and the quantity of salt necessary to dissolve in one liter to yield this strength is given in column 5 of the table. Other data which it is believed will be of service in the preparation of stock solutions of other strengths are given, viz., formula weight, solubility in cold water, and the percentage of metal in the salt.

Our stock solutions are prepared in one or two liter quantities and kept in bottles provided with graduated pipettes. We are thus able to deliver definite quantities of these standard solutions to students' "unknown" bottles; these are homeopathic vials of 50 cc. capacity. For the analysis the student uses 25 cc. of his solution, the other half being reserved in case the analysis is to be repeated. The amounts of standard solutions pipetted out should be such as to yield a suitable concentration[2] when the volume is diluted to 50 cc., i. e., when the unknown bottle is filled. An example will make this clear. Pipette out into unknown bottle 1 cc. NaCl solution, 2 cc. $Ca(NO_3)_2$, and 1 cc. of NH_4NO_3, and then fill the bottle with distilled water. Since the student uses only 25 cc. of this solution, this quantity will contain 50 mgs. Na, 100 mgs. Ca, and 50 mgs. NH_4. Our qualitative unknowns are prepared of such strength that the total weight of metal in 25 cc. never exceeds 1.5 grams though it usually is kept within 1 gram. The minimum will depend upon the scheme of analysis employed. It may be exceedingly small if the most sensitive tests are used, e. g. the spectroscopic tests for the alkali and alkaline earth metals, the KCNS test for Fe, and the Marsh and Gutzeit tests for As and Sb. But if it is desired that the student report roughly the relative proportions of the ingredients present, precipitation methods will be largely used which by the size of the precipitates they yield, give indications of the approximate quantities of the metals present. In the latter case the minimum quantity of metal present in 50 cc. will have to be much larger than it is in the first case. The above table gives data only for the metals; another is in preparation

[2]If it is desired that the Pb should be precipitated in the silver group, it is important that the amount of Pb in 50 cc. exceed 100 mgs.

for the acids. Since these tables are gotten up primarily for the instructor in qualitative analysis, the salts have been arranged in groups corresponding to the analytical classification of the metals.

If when issuing his unknowns, the instructor will note the quantities of standard solutions pipetted out for each unknown, and record the results obtained by the student, he will obtain valuable information which will be of great service in the preparation of unknowns in the future. The great elasticity of the system places within the control of the instructor a limitless range of possible mixtures; and in every case where note is kept of the volumes pipetted out, there is also recorded at the same time the precise qualitative and quantitative composition of the mixture issued.

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GENERAL BIOLOGY.

By W. L. Eikenberry,
School of Education, University of Chicago.

Since the beginning of biological teaching in the modern sense the peculiar seeming parallelism of botany and zoölogy has tempted people to try to combine them under the form of a course in general biology. There has resulted a multiplicity of courses and text-books whose very number and variety bespeak dissatisfaction with the results.

In general, the combined course has consisted of two wholly distinct elements which were not correlated or harmonized in any effective way. Sometimes the two parts, botany and zoölogy, have been taught simultaneously in separate departments, sometimes consecutively by the same or different teachers, sometimes both have been intermingled, but always the subject-matter of the two life-sciences stood out as sharply distinguished from each other as the black sheep from the white in a mixed flock.

The present tendency toward the use of "immediately useful" or economic materials has stimulated the attempt to organize the old materials of general biology about human hygiene in order to give some sort of continuity to the whole. Just what real connection the teachers may in practice succeed in giving to such a course it is not the province of this paper to present; but upon the face of the printed courses and texts it would appear that the result has been to add to the old dual course a third element already familiar in the schools as human physiology. That there is actually more connection between the parts than appears on the surface is doubtless true, but such connection is dependent upon the personal equation of the teacher and exists rather in spite of the formal organization of the materials than in consequence of it. With respect to the texts, it is interesting to note that the three parts may be so wholly independent that they are issued without change, separately bound, for use in those schools in which only one of the sciences is taught. The old authors with their natural history have in many respects come closer to a solution than we with our biology.

The difficulty of the whole matter seems to be in the fact that botany and zoölogy are in fact divergent rather than parallel sciences; that in respect to morphology they are very widely divergent; and that the makers of text-books and courses have largely ignored as the organizing principle the only thing in com-

mon between animals and plants—the phenomena of life. It seems axiomatic that a combined course on the basis of morphology cannot exist.

The increasing interest in the economic phases of the sciences has stimulated the suggestion that the grouping of materials might be made about man's interest and activity, relating everything to man's use and regarding everything from the point of view of its utilization by him. This certainly has the advantage over former courses that a coherent classification is possible, and that the course can be organized as a unit. It is open to doubt, however, whether such a self-centered arrangement of the pupil's environment is desirable either scientifically or pedagogically.

There was a time in the development of the race when each nation, possibly each individual, felt that it was the center of the earth, that the earth was the center of the solar system, and that the solar system was the center of the universe. Enlightened peoples have eliminated this from their thought and are able to smile at the egoism of China or Turkey. To the child or the ignorant, however, his own place and people are the center of things; the world is for him "Greek and barbarian" only. It is one of the tasks of education to enable him to see himself in his proper place in the world, in order that he may understandingly apply himself to his individual and social tasks. To organize one of his subjects of study, and particularly a science, from such a standpoint as we have mentioned would be rather too medieval, too Ptolemaic, to enable it to long hold its place in this age.

There is the further disability that when a science is organized with reference to man's more or less random utilization of its materials, such great gaps are left in its structure that it becomes merely a collection of unrelated fragments; it ceases to be a science. The most heterogeneous things are often brought together by man for his purpose as when a building is constructed of burnt clay, limestone, hair, pine wood, sheet iron, and a multitude of equally diverse materials. If these things be studied from the viewpoint just mentioned any knowledge of those characteristics which are not intimately connected with their availability as structural materials is merely a collection of fugitive items without relation or connection. The mind may become stored with "a thousand wonders of land and sea" but if these facts be unrelated and unconnected its condition is after all somewhat

comparable to that of a dictionary which an acquaintance of mine described as "mighty interesting reading but powerful disconnected."

Unrelated facts are of course unexplained and such a mass of highly interesting information is known only in an empirical way as much of it was known long before the birth of the sciences. If a *science* is to be taught the gaps must be filled up in such manner that the knowledge will be, if not continuous, at least orderly. This does not necessitate the omission of the materials selected from everyday life and related to human needs but it does require a careful selection among these and the addition to the "practical" materials thus selected of those more practical materials which are fundamental to an understanding of the field and from which most of the practical scientific knowledge has arisen.

Now as to the bearing of this on general biology. Negatively, we must realize, that a course in general biology is not made so by the title or by the binding of a book; that there is little in morphology that is common to the two sciences; that there are few life processes which are actually identical in the two sciences; and that in deriving a knowledge of these common facts the pupil can be instructed in either science, a *general* course not being an absolute necessity. Until by slow steps we have evolved a combined course we shall doubtless secure results and preserve our self-respect best by frankly denominating most of our work *botany* and *zoölogy*.

In those schools where pupils take both botany and zoölogy a great service might be performed by teachers who would attempt to instruct classes in certain fundamentals which are common to both sciences before entering upon the separate courses, and reporting the results. There ought not to be a complete course organized at first. Let it be an evolution. If there is but a single week's work of that sort the first year, do that, and hope for future growth. If we ever have a real general biology course it will be as the result of the experiments of those who are working with secondary school classes and it will be the growth of years, contributed to by many experimenters. When a mass of results of this sort have accumulated and been placed on record it will be possible to answer positively the question as to how a course in general biology should be organized.

AN ATTEMPT TO ADAPT ELEMENTARY GEOMETRY TO THE UNDERSTANDING AND INTERESTS OF YOUNG PEOPLE.[1]

By N. J. Lennes,
Massachusetts Institute of Technology.

In organic evolution changes of environment often demand that physical structures perform functions quite different from those for which they were first developed. When the work required of an organ is thus changed we may with good reason expect to find it more or less imperfectly equipped for its new duties. Indeed this is recognized as one of the chief reasons for ill adaptation of structure to functions. Ill adjustment of school curricula to the needs of the pupil in respect either to subject-matter or to mode of presentation is often due to causes similar to those of biological maladjustment.

With minor exceptions, such as children's stories, practically the whole intellectual output of the human race is first formulated for mature minds. The great histories are written in the language and from the point of view of the historian. The grammar of any language was first formulated by and for the specialist in language, and so on through the list. *A priori* it is very probable that when any such subject is to be presented to young pupils it requires extensive restatement with special reference to their needs. The question whether a given subject as treated in our schools is adapted to the pupil leads therefore to the inquiry: Was its original formulation suited to young pupils, and if not has it been restated so as to bring the subject effectively within the range of their powers and interests? We now make these inquiries concerning geometry.

In Egypt a number of simple geometric theorems were known and used in the practical arts. But there is no evidence of a theoretical development such as was produced by the Greeks. We do not know that the Egyptians "proved" a single theorem after the manner of Euclid.

In Greece these Egyptian fragments of geometric information were greatly extended and finally elaborated into a finished logical system such as we find in our present texts. Thales, Pythagoras and other early Greeks discovered great numbers of theorems and used them in practical applications. Later Aristotle, Plato and their disciples added much to the subject-matter

[1] An address delivered before the Connecticut Teachers Association in New Haven, March 6, 1909.

of geometry and developed the method of treatment which was later used by Euclid. In their hands it became largely speculative and philosophical. Plato, in particular, insisted on the purely logical character of geometry. At his instance mechanics and other practical subjects were separated from it. Theorems were added not because of any practical value but because of a desire for symmetrical and complete treatment. Propositions which are perfectly obvious were given elaborate proofs. The questions at issue were not whether the propositions were *true* but whether they could be deduced from preceding ones. The meaning of the words "definition," "axiom," "proof," and other purely logical concepts was discussed in a manner surprisingly similar to our modern treatment. Deductive geometry as thus treated was particularly attractive to the speculative Greek mind. Its fundamental principles and its purely deductive reasoning were formulated in harmony with Plato's abstract philosophy. It was this philosophy of space formulated by the greatest and most profound of Greek minds which Euclid wrought into his immortal "Elements."

These "Elements" are essentially the geometry which we teach to the boys and girls of our secondary schools. The order of the subject-matter has been changed somewhat, but the presentation is exactly in the spirit of Euclid. Like him we still give proofs of theorems which are entirely obvious. Complicated propositions are studied which are of no importance for subsequent work and which find no practical applications. The proofs are strictly deductive from the very start. Is it not very probable, indeed, that this Greek philosophy of space, formulated for the mature philosophers of that profound race, is ill-adapted both in subject-matter and in mode of treatment to our boys and girls of fourteen and fifteen years of age?

That the instruction in secondary mathematics and especially in geometry has not fully adjusted itself in accordance with the new pedagogy[2] will be admitted. The departure from the order of Euclid is of no fundamental pedagogical importance. The so-called *inductive method*, which consists essentially in asking why, instead of quoting theorems, axioms, and definitions in full at every step, has the merit of securing more activity on the part of the student, and that is an important gain. A large number of originals have been introduced which are of a grade of difficulty fairly well suited to the pupils for whom they are intended.

[2] See *Mathematics Teacher*, Vol. I, No. 3, pps. 96 and 97 (1909).

Algebraic methods are used sparingly. But even the originals are to be exactly after the manner of Euclid. Everything is to be proved. There is little demand for *mathematical common sense*. It will be instructive at this point briefly to compare with our well-known standard course in geometry the courses given in some of the most important European countries.

The curricula of the various kinds of English schools differ so much among themselves that it is difficult to make any general statement that is not subject to an overwhelming number of exceptions. The English boy begins the study of geometry at an early age, say eleven or twelve, and continues it during a number of years varying from three to six, four years being, perhaps, a fair average. During this time he also studies *practical geometry* and mechanical drawing, algebra, and some trigonometry. The pure geometry, however, is given as a distinct subject, and Euclid is followed quite closely. The amount of pure geometry studied during the first year is very small, perhaps not more than half of our first book.

Instruction in geometry in France is sufficiently similar to that in Germany to permit a common characterization. The subject is begun at the age of eleven or twelve, and continues for five or six years. The work of the first year is almost entirely concrete. The ordinary instruments for constructing figures are used, and the pupil learns facts about geometry in a variety of ways. "The first work is practical and the transition into the logical quite gradual. * * * When the scientific study is begun algebraic methods are used wherever opportunity offers." [3] The solution of triangles by the methods of trigonometry is studied as soon as the subject of similar triangles is reached. In the latter years of the course the mathematical subjects are so mixed that one often cannot tell whether algebra, geometry or trigonometry is receiving the chief emphasis.

We see, then, that the courses of instruction in geometry in these three countries differ from ours in certain common elements, the most important being that they extend over a period of years and that during this time other mathematical subjects are being studied, either in direct union with geometry as in France and Germany or separately as in England.

Further comparison would only serve to show more fully that

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[3] Alva Walker Stamper. History of the Teaching of Geometry.

with us geometry is more sequestered than in any other country where it is studied—even more so than in England.

It is not suggested here that we should copy any of these systems. Indeed, with our non-centralized authority it would hardly be possible to effect general changes in our curricula which should extend the study of geometry over a number of years and combine it with other subjects. In all probability for a long time to come the study of geometry in the average American high school will be confined to a short period not exceeding one year or one and a half years. Hence whatever immediate improvements we are to look for must contemplate a short and rather forced course in geometry with no other mathematical subjects studied at the same time.

It is obvious that this greater isolation of geometry with us requires more careful adjustments to the age and maturity of the pupil and more rational coördination with life. The purely deductive argumentation of geometry is entirely different from anything in the pupil's previous experience. He has been accustomed, as people are in their daily lives, to convince himself of the truth or falsity of a statement by means of *all the resources at his command.* In geometry he is told at the very beginning that he must prove his statements by means of a very limited part of the evidence that is available and apparently conclusive. In the absence of the English expedient of going very slowly over this strange ground at the outset, is it not clear that we must adopt some other means by which to render the transition natural?

Let the formal argumentation be approached gradually. Let a large number of simple propositions be made evident in an *informal* way by remarks which are not strictly deductive, until propositions are reached of whose validity the pupil is not so certain. He will then not argue to prove what he already knows to be true, but for each argument there will be something at stake. The cogency of the proof will thus be felt. The argumentation will of itself become more and more purely deductive as the theorems become more complicated, and the direct intuition serves less and less to convince of the truth or falsity of the statements. In this way the transition from the informal argumentation of life to the formal, deductive processes of geometry may be made natural and the pupil will be permitted to *grow* into the new method of thinking.

Second only in importance to this natural transition into formal logic is the real appreciation of the theorems of geometry not merely as statements in a book but as *facts of the space in which we live*—facts which condition our every movement—facts the understanding of which is absolutely necessary for that mastery of the environment which distinguishes the civilized man from the savage. This can best be done by the introduction of concrete problems from familiar and interesting objects. In this way it may be shown how each additional theorem has enabled man to do things which he could not do without it or could do only with greater difficulty.

Consider as a special instance the problem of obtaining the distance from an accessible to an inaccessible point. Without any knowledge of geometry the problem seems impossible. With the first congruence theorems we are enabled to measure such distances in simple cases, but only in each case by the construction of a triangle one of whose sides is as long as the distance to be measured. The process of laying out this large triangle may be very laborious, but nevertheless it has now become possible to achieve something which before was impossible. The theorem by means of which it is accomplished thus acquires a certain dramatic interest. It is an achievement of *orderly thinking* quite impossible by *mere labor*.

Later, by means of similar triangles, we learn to solve the same problem by constructing a small and convenient triangle similar to the large one necessary in the first attempt. If now a little trigonometry is introduced, with a short table of sines, tangents, etc., the pupil will have a glimpse of the first principles of modern surveying. As we proceed we note at each step that the direct measurements required are increasingly simple and convenient, while the theorems involved are increasingly complex.

What cultural value may we not claim for this kind of study of geometry! The pupil is led to see how step by step intelligence gradually takes the place of mere toil. What an epitome of the long march of human evolution from the helpless savage to the masterful man of modern civilization! If the theorems of geometry are thus made to appear to the pupil as they are in fact, great elements of achievement in man's tragic struggle to lift himself above the savage, to render himself immune from the thousand terrors that beset the wild man of the forest—a new and strange life will be infused into the study of geometry.

The aims of education are, among others, to impart useful

and significant information and to develop right habits of thought and high standards of intellectual interests. Facts find their significance and value in their relation to the general ends of human life. An isolated fact is never significant, and a knowledge of it is therefore of little worth. Moreover, unrelated facts quickly slip from the memory. It is easier to remember five facts related by obvious connections than one solitary, unrelated fact. So it is easier to remember a number of geometric theorems if their relations to each other and to the rest of the world are to some extent apprehended, than to remember a single theorem which is seen in no such relation. But more important than the learning of significant facts and the understanding of their relations and significance is the creation in the individual of standards of interest which will cause him to discriminate between what is essential and what is merely incidental, and to seek to know the essential and to understand its significance for human life.

The most spontaneous and most permanent interest can be created only by showing the pupil relations between what he is studying and that world with which he is already familiar. Suppose a man were to explain the mechanics and general construction of an airship to a class of boys who had never heard of such a thing and who were not led to suspect the use of the machine from its name or appearance. The class is assembled before him and the curious looking machine is mounted in full view. He exhibits its various parts. Here is a shaft with two blades at the end of it. There are great planes made of bamboo and canvas and little planes on the sides. In the middle is a chair, and a man seated in it can move the little planes by merely leaning his body. There are levers by means of which he may move a horizontal plane in front and a vertical plane in the rear. There is an engine which may be made to turn the blades rapidly.

All its parts are thus studied minutely for a term of weeks and an examination is given at the end of the course. Many of these boys study the machine most assiduously, at first because they are told that it is the thing to do and because it is creditable to pass examinations, and later because they learn to like it as one usually learns to like any activity in which he is engaged. Never does the instructor mention that the thing can be made to fly, and the boys never suspect it. If he is asked why he does not disclose to them this momentous secret he will

answer that he does not wish to divert the attention from the main subject, which is to learn the morphology and not the physiology of the machine. He has himself studied such machines in company with other mature men, and at times has become so engrossed in the details of the mechanism that he was quite oblivious to the fact that it was a flying machine. Hence, why should not these boys get on equally well in the study of its mechanism though they do not know the marvelous feats of which it is capable? Later on when they have mastered the details of its construction and know how each part may be moved by the proper lever, then it is time enough to initiate them into aviation. This procedure is perfectly *logical*. To carry the analogy to the proper extent we should study *drawings* of the machine instead of the machine itself. This would assist in developing the student's power to image complicated objects in space.

Is it not a most remarkable doctrine that in this world where each one of us finds innumerable things too difficult to understand under the most favorable conditions it should be thought necessary to develop power by making things needlessly difficult?

This is not a plea for concreteness in any absolute sense, but merely for frequent and vital connections with what is already known and interesting. In urging this view I am frequently met with the statement: "Newton or Leibnitz or someone else did not work this way." But I believe that is exactly what they did. The significance of the problem which they investigated was clear to them before the investigation began. Indeed, I am inclined to believe that the man doing original research is always occupied with problems of whose significance he is aware. It is too often the student who is put to work by someone else who may truthfully say, "I do not know where I am going, but I am on my way."

The question at issue is not whether the so-called practical or even the concrete shall be given preference over the abstract. It is rather as to how the concrete and practical on one hand and the abstract on the other may be made to illuminate each other and to lend mutual interest. It is not urged that the abstract be decreased in importance but that it be galvanized into life and given real meaning to the child by judicious use of that which he already knows.

GEOMETRIC CONSTRUCTIONS.

By W. W. Beman,
University of Michigan.

The solution of problems as presented in the study of Euclidean geometry is effected by the use of the classical instruments, the straight edge and the compasses in combination. In the secondary schools of this country, at least, little attention has been given to the possibility of dealing with these problems by the use of the straight edge alone, the compasses alone, the ruler (with parallel edges), the square (the carpenter's square ungraduated, i. e., a right-angled triangle without hypotenuse), and so on. It is obvious that the straight edge alone is less powerful than the straight edge and the compasses together, but it is by no means so manifest that all problems that can be solved by the use of the straight edge and the compasses together can be solved by the use of the compasses alone, by the use of the ruler alone, by the use of the square alone, by the use of the straight edge in combination with a fixed circle; nor is it manifest that by the use of two squares one can trisect an angle, duplicate a cube, construct a regular heptagon, in fact solve any equation of the third or fourth degree.

The general theory of geometric constructions by various of these methods has been discussed in Klein's Vorträge über ausgewählte Fragen der Elementargeometrie, Leipzig, 1895 (English translation with title, Famous Problems of Elementary Geometry, Ginn & Co., Boston); more fully in Enrique's Questioni riguardanti la geometria elementare, Bologna, 1900 (German translation of Part II with title, Fragen der Elementargeometrie, Leipzig, 1907); and perhaps best of all in Adler, Theorie der geometrischen Konstruktionen, Leipzig, 1906.

There seems little doubt that problems to be solved by these more modern methods may rouse interest on the part of wide-awake students of elementary geometry and accordingly a short list is appended.

Constructions with the Straight Edge Alone.

1. Through a given point to draw a line that shall pass through the inaccessible intersection of two given lines.
2. Through a given point to draw a line that shall be parallel to a given line on which two equal adjacent segments have been laid off.
3. To bisect a line segment lying on one of two given parallels.
4. Through a given point to draw a line parallel to two given parallels.
5. Having given a parallelogram, through a given point to draw a line parallel to a given line.

Constructions with the Compasses Alone.*

1. Through a given point to draw a line parallel to a given line.
2. To double, treble a given line segment.
3. To determine the symmetric of a given point with respect to a given line.
4. To construct the fourth proportional to three given line segments.
5. To determine the center of the circle passing through three given points not collinear.
6. To bisect a given line segment.
7. To bisect a given arc.
8. To construct a square with two vertices given.

Constructions with the Ruler Alone.

1. Through a given point to draw a line parallel to a given line.
2. Through a given point to draw a line perpendicular to a given line.
3. To bisect an angle.
4. To double, treble, a given angle.

Constructions with the Square Alone.

1. To double, treble, a given line segment.
2. To bisect a given line segment.
3. To double, treble, a given angle.
4. To bisect a given angle.
5. Through a given point to draw a line making with a given line an angle equal to an angle given in magnitude and sense.

*In constructions with the compasses alone no straight lines are actually given or drawn. The line is determined by two points upon it.

A novel method of recovering a sunken cargo has been adopted by the United States Steel Company. A large magnet, 3½ feet in diameter and weighing 3,000 pounds, has been employed in raising kegs of nails from a barge that was sunk in the Mississippi River near New Orleans. The magnet raised five or six kegs at a time, or about a ton at each lift. The advantage of this method was that it avoided breaking open the kegs, as would have been the case had a dredge been used. The magnet is soon to be used for raising a sunken load of woven wire, and also for a load of steel baling strips.

The most recent report of the Commissioner of Education states that the total number of graduates of public high schools in June, 1908, was 90,232, of whom 28,895 were college preparatory students. In addition there were 11,940 graduates preparing for higher institutions.

In other words, 45.25 per cent of all our public high school graduates in 1908 were planning to go on with their education in higher institutions, and 32.02 per cent were actual college preparatory students. In private schools there were 11,279 graduates in 1908, of whom 4,877, or 43.24 per cent, had prepared for college.

LIMITS IN ELEMENTARY GEOMETRY.

By Ernest B. Lytle,
University of Illinois.

Recently in a teachers' course in geometry in an eastern university the professor said, "In ten years I have not seen more than five undergraduate students in this university who could understand the theory of limits." In a teachers' course given last summer by the writer he received numerous requests to discuss the topic of limits and, while this class had many members who had taught geometry in some high school, not a single member of that class could give a satisfactory definition of a limit. College instructors testify that rarely do any freshmen come to them with a correct notion of a limit. These facts surely point to some weakness in teaching limits in our high schools and it will be useful to endeavor to determine the cause and remedy for this weakness.

Students generally enter college remembering just two words about limits, namely, "never reaches." This is probably due to the over-emphasis of these words in connection with the definition of a limit by both teachers and text-books. To say that a variable *never reaches* its limit is not only incorrect but also casts about the notion of a limit an atmosphere of mystery in the minds of young students. They lose some faith in the exactness of mathematics in using a constant as if equal to a variable when their definition says a variable never reaches its limit. It would greatly clarify the notion of a limit if the words *"never reaches"* were crossed out of every single definition of limit in our text-books. Whether or not a variable reaches its limit has nothing whatever to do with the notion of a limit but is entirely concerned with the question of continuity, a notion which need not bother elementary students. *"A limit of a variable is a constant which that variable approaches as near as you please in value and remains near."* While it is true that the variables considered in elementary geometry are generally discontinuous and hence do not reach their limits, yet this fact is *not* a defining characteristic of the limit notion, and making it such spoils the definition for use in continuous cases met later; and besides tends to inexactness and mystery in the minds of our students. The writer knows but three American elementary geometry texts which correctly define a limit. Within a month he has received copies of two

new geometries which contain the old and incorrect definition of a limit.

Since the variables of elementary geometry always increase or always decrease (are monotone), a limit can first be presented as a value to which a variable comes as near as you please but cannot go beyond, which is the common everyday notion of a limit as a boundary which stops or hems in something. In later work the above definition needs no modification but only a more precise quantitative form of statement.

Besides incorrect definitions, the attempt to prove difficult existence theorems is another cause for the present difficulties in the theory of limits in elementary classes. To prove that a particular variable has a limit, leaving out all question as to the value of this limit, is frequently a difficult task of higher mathematics. It is questionable whether or not existence proofs and difficult evaluations of limits have any place in elementary courses; certainly if retained their old treatment as found in most texts to-day should be modified and simplified. This simplification can well be made by assuming the following fundamental theorem: *"If a variable always increases (or always decreases) and is always less than (or greater than) some finite constant then it has a limit."* No attempt should be made to prove this theorem in an elementary course, but students with a correct limit notion will readily accept the truth of this theorem on intuition from a few illustrations. There is no objection to a rather free use of unproved assumptions in beginning courses so long as they are consciously made and explicitly marked as assumptions but do not creep in unconsciously under cover of such terms as *obviously* and the like. In many cases it is quite simple to show that a variable always increases and is always less than some finite constant; then by the use of the above theorem the variable is known to have a limit. Existence theorems which do not come under this simple treatment should be omitted entirely from elementary geometry.

The theorem ordinarily given as the fundamental theorem of limits, namely, "If two variables are constantly equal and each approaches a limit, then their limits are equal," is almost trivial, for if two variables are constantly equal they are the same variable and of course have equal limits if any at all. This theorem by no means deserves the emphasis generally given to it.

It is being suggested in some quarters that limits and all work involving limits should be entirely omitted from courses in ele-

mentary geometry because of their difficulty and the present unsatisfactory results. The writer disagrees with this suggestion because of the importance of the limit notion in the treatment of incommensurables and because the limit idea is needed in certain definitions. Such notions as length of a circumference, area of a circle, volume of a cylinder, lateral area of a cylinder, volume and the lateral area of cone, and surface of a sphere require the idea of a limit in their definitions. Many present day texts in geometry try to prove as theorems statements which properly should be assumed as definitions; e. g., "The circumference of a circle is the limit which the perimeters of regular inscribed polygons and of similar circumscribed polygons approach if the number of sides of the polygons is indefinitely increased" (Wentworth, Book V, Prop. VIII, p. 220). This is a *definition* of the length of a circle and a definition needs no proof.

The notion of a limit is too important and too useful to be dropped out of elementary geometry. The writer strongly believes that limits can be presented in a form sufficiently simple to be understood by high school students and to this end sums up his suggestions as follows: 1. Teach a *correct* but not the most precise definition of a limit, taking care to avoid the words *"never reaches"* which are incorrect and tend to mystify. 2. Prove the existence of limits only in such simple cases of monotone variables which come under the assumed fundamental theorem quoted above. 3. Eliminate many difficult "proofs" of present day texts by *defining* all lengths of curves, areas bounded by curves, areas of curved surfaces, and volumes bounded by curved surfaces as particular limits.

MAKING BOARDING HOUSES SANITARY FOR STUDENTS.

The following shows how carefully the authorities of the University of Wisconsin are looking after the health of its students:

A thorough inspection of all rooming and boarding houses for students at the University of Wisconsin has been begun under the auspices of the hygiene committee of the faculty, to determine fully the sanitary and hygienic condition of each.

This is the first time that the score-card system of regulation of living conditions for students at the university has been applied.

A full report of the ventilation, plumbing, cleanliness, lighting, heating, and general surroundings is to be made out by the inspector and kept on file in the office of the committee. Defective conditions found are to be reported to the owner and occupant, and steps will be taken to compel all offering accommodation for students to maintain a reasonable standard of living conditions.

PROBLEM DEPARTMENT.

E. L. BROWN.
Principal North Side High School, Denver, Colo.

Readers of the magazine are invited to send solutions of the problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to E. L. Brown, 3435 Alcott St., Denver, Colo.

Algebra.

201. *Proposed by Franklin T. Jones, Cleveland, O.*

Find the value of $\frac{21 \times 143}{34}$, the numbers being written in the scale of seven. Perform the indicated multiplication and division in the scale of seven, then change the numbers to the scale of ten and verify your results. (From a Harvard examination in Advanced Algebra.)

Solution by E. M. Venables, Philadelphia, Pa.

Scale of 7.	Scale of 10.
$21 = 2\times7+1$	$= 15$
$143 = 1\times7^2+4\times7\times3$	$= 80$
$34 = 3\times7+4$	$= 25$

$$\begin{array}{r} 143 \\ 21 \\ \hline 143 \\ 316 \\ \hline 34)3333(66 \\ 303 \\ \hline 303 \\ 303 \\ \hline \end{array} \qquad \begin{array}{r} 15 \\ 80 \\ \hline 25)1200 \\ 48 \end{array}$$

$66 = 6\times7+6 =$ 48

202. *Proposed by H. E. Trefethen, Kent's Hill, Me.*

If $u > v > z$, show that $\left(\frac{u+z}{u-z}\right)^u < \left(\frac{v+z}{v-z}\right)^v$.

I. Solution by W. L. Brown, Albion, N. Y.

Let $\frac{u}{z} = x$ and $\frac{v}{z} = y$; then $x > y > 1$. We must now show that $\left(\frac{x+1}{x-1}\right)^x < \left(\frac{y+1}{y-1}\right)^y$, or $\left(1+\frac{2}{x-1}\right)^x < \left(1+\frac{2}{y-1}\right)^y$,

or $1+\frac{2}{x-1}\cdot x+\frac{x(x-1)}{2}\cdot\left(\frac{2}{x-1}\right)^2\ldots < 1+\frac{2}{y-1}\cdot y+\frac{y(y-1)}{2}\cdot\left(\frac{2}{y-1}\right)^2\ldots$

Now $\frac{x}{x-1} < \frac{y}{y-1}$, since $(xy-x)-(xy-y)=y-x$, a negative quantity.

Likewise $\frac{x(x-1)}{2}\cdot\left(\frac{2}{x-1}\right)^2 < \frac{y(y-1)}{2}\cdot\left(\frac{2}{y-1}\right)^2$. Similarly each term of $\left(\frac{x+1}{x-1}\right)^x$ is less than the corresponding term of $\left(\frac{y+1}{y-1}\right)^y$, except the first term which is the same.

Hence $\left(\frac{x+1}{x-1}\right)^x < \left(\frac{y+1}{y-1}\right)^y$, and $\left(\frac{u+z}{u-z}\right)^u < \left(\frac{v+z}{v-z}\right)^v$.

II. Solution by I. L. Winckler, Cleveland, Ohio.

If $\left(\frac{u+z}{u-z}\right)^u < \left(\frac{v+z}{v-z}\right)^v$ then $u \log \frac{u+z}{u-z} < v \log \frac{v+z}{v-z}$,

or $2u\left\{\frac{z}{u}+\frac{z^3}{3u^3}+\frac{z^5}{5u^5}+\ldots\ldots\right\} < 2v\left\{\frac{z}{v}+\frac{z^3}{3v^3}+\frac{z^5}{5v^5}+\ldots\ldots\right\}$

or $z+\frac{z^3}{3u^3}+\frac{z^5}{5u^4}+\ldots\ldots < z+\frac{z^3}{3v^3}+\frac{z^5}{5v^4}+\ldots\ldots$

Since $u > v$, the latter inequality is easily seen to be true

and $\therefore \left(\frac{u+z}{u-z}\right)^u < \left(\frac{v+z}{v-z}\right)^v$.

203. *Proposed by G. B. M. Zerr, Philadelphia, Pa.*

Extract square root of $1+12\sqrt{-3}-4\sqrt{-6}+6\sqrt{2}$.

Solution by H. E. Trefethen, Kent's Hill, Me.

I. Since the given expression has a rational term but no radical of higher degree than the second, the required root has none, for if it did the higher radical would appear in the power. It follows that we may put $1+12\sqrt{-3}-4\sqrt{-6}+6\sqrt{2}=(a+b\sqrt{-1}+c\sqrt{-1})^2=a^2-b^2-c^2+2ab\sqrt{-1}+2ac\sqrt{-1}-2bc$, and $2ab=12\sqrt{3}$, $2ac=-4\sqrt{6}$, $2bc=-6\sqrt{2}$. Whence $a=\pm 2\sqrt{3}$, $b=\pm 3$, $c=\pm\sqrt{2}$, and the root $=\pm 2\sqrt{3}\pm 3\sqrt{-1}\mp\sqrt{2}\sqrt{-1}=\pm 3.4641 \pm 1.5857\sqrt{-1}$. (Pairing either the upper signs together or the lower).

II. If we put $x=\rho\cos\theta\ldots.(1)$, $y=\rho\sin\theta\ldots.(2)$, $x^2+y^2=\rho^2\ldots.(3)$ we may put $1+6\sqrt{2}+(12\sqrt{3}-4\sqrt{6})\sqrt{-1}=x+iy=\rho(\cos\theta+i\sin\theta)=\rho cis\theta$, $x=1+6\sqrt{2}$ and $y=12\sqrt{3}-4\sqrt{6}$. Hence by (1)(2)(3)$\rho=23-6\sqrt{2}$, $\theta=49°11'40''$ and by DeMoivre's theorem we infer that $\sqrt{1+6\sqrt{2}+(12\sqrt{3}-4\sqrt{6})i}=\sqrt{\rho}\,cis\frac{\theta}{2}$ or $\sqrt{\rho}\,cis(\theta/2+180°)=3.4641+1.5857i$ or $-3.4641-1.5857i$, where $\sqrt{-1}=i$.

III. Put $1+(12\sqrt{3}-4\sqrt{6})\sqrt{-1}+6\sqrt{2}=(x+y\sqrt{-1})^2=x^2-y^2+2xy\sqrt{-1}$, $x^2-y^2=1+6\sqrt{2}\ldots\ldots.(1)$, $2xy=12\sqrt{3}-4\sqrt{6}\ldots\ldots.(2)$. From (1) and (2) $(x^2+y^2)^2=601-276\sqrt{2}$, $x^2+y^2=23-6\sqrt{2}\ldots\ldots.(3)$. From (1) (3) $x=\pm 2\sqrt{3}$, $y=\pm(3-\sqrt{2})$. Since x^2+y^2 is always positive, we cannot give the double sign to its value in (3). Since in (2) the value of $2xy$ is positive, x and y must have like signs. Thus the two square roots are $2\sqrt{3}+3\sqrt{-1}-\sqrt{-2}$ and $-2\sqrt{3}-3\sqrt{-1}+\sqrt{-2}$.

Geometry.

204. *Proposed by Norman Anning, Challiwick, B. C., Canada.*

Given, as centers, three points which form the vertices of an acute-angled triangle; describe three mutually orthogonal circles.

I. Solution by Jas. A. Whitted, Abingdon, Ill.

Let ABC be the given triangle. Let the altitudes AD, BE, and CF intersect in O. Then the three circles having A, B, C as centers, and $\sqrt{AO\cdot AD}$, $\sqrt{BO\cdot BE}$, $\sqrt{CO\cdot CF}$ as radii, will intersect orthogonally.

The points D, O, E, C are concyclic. $\therefore$ $BO\cdot BE=BC\cdot BD\ldots\ldots.(1)$

Similarly, $CO\cdot CF=DC\cdot BC\ldots\ldots.(2)$

From (1) and (2) $BO\cdot BE+CO\cdot CF=BC\cdot BD+DC\cdot BC$ or $BO\cdot BE+CO\cdot CF=BC^2$. That is, the sum of the squares of the radii of circles B, C equals the square of the line joining their centers, which shows that they intersect orthogonally. The same is true for circles A and C, and circles A and B.

The circle round O as a center, the square of whose radius equals $OA \cdot OD$ is the polar circle of the triangle ABC. Since OA and OD are measured in opposite directions, and therefore have contrary signs, the polar circle is imaginary. However, even in this case we have $AO \cdot AD + OA \cdot OD = AO \cdot AD - AO \cdot OD = AO^2$. That is the sum of the squares of the radii of the circles A and O is equal to the square of the line joining their centers.

II. Solution by H. G. McCann, Kent's Hill, Me.

Let ABC be the given triangle. On AC as diameter describe a semicircle cut at P by the perpendicular to AC from B. With A as center and radius = AP, with C as center and radius = CP, describe circles A and C. From B draw tangents BO, BR to circles A, C. With B as center and radius = BO = BR, describe circle B. The circles A, B, C are mutually orthogonal, since for each pair their radii to a common point are at right angles.

205. *Proposed by I. L. Winckler, Cleveland, O.*

From any point P in the bisector of the angle A in a triangle ABC, perpendiculars PA′, PB′, PC′ are drawn to the three sides. Prove PA′ and B′C′ intersect in the median from A.

I. Solution by A. M. Harding, Fayetteville, Ark.

Let PA′ and B′C′ intersect at K. Draw through K a line parallel to BC cutting AB at x and AC at y. $\triangle PB'C'$ is isosceles; therefore $\angle B' = \angle C'$. The points P, K, y, B′ are concyclic; hence $\angle y = \angle B'$. The points P, x, C′, K are concyclic; hence $\angle x = \angle C'$. $\therefore \angle x = \angle y$, and $\triangle Pxy$ is isosceles. Hence K is the mid-point of xy, since PK is perpendicular to xy. $\therefore$ K is on the median through A.

II. Solution by T. M. Blakslee, Ames, Ia.

Let A′P, prolonged, cut B′C′ in D. $\angle DPB' = C$. $\angle DPC' = B$. Triangles DPB′ and DPC′ show that D divides B′C′ in ratio $\sin C : \sin B = c : b$.

Let median AM cut B′C′ in E. Triangles AMC and AMB show that $\sin EAB' : \sin EAC' = \sin C : \sin B = c : b$.

Then triangles EAB′ and EAC′ show that E divides B′C′ in ratio $c : b$. Hence E and D coincide.

III. Solution by G. B. M. Zerr, Philadelphia, Pa.

Let $PB' = PC' = m$, and $AB' = AC' = x$. Then $B'C' = 2m \cos \frac{1}{2}A = 2x \sin \frac{1}{2}A$. $\therefore x = m \cot \frac{1}{2}A$. With A as origin, AB, AC as axes of coördinates,

we have $\frac{x}{c} + \frac{y}{b} = 1$ for equation of BC, ...(1)

$x + y = m \cot \frac{1}{2} A$ for equation of B′C′, ...(2)

$bx = cy$ for the median through A. .....(3)

(2) and (3) intersect in $\left(\frac{cm \cot \frac{1}{2} A}{b + c}, \frac{bm \cot \frac{1}{2} A}{b + c}\right)$ ....(4)

The coördinates of P are (m cosec A, m cosec A).....(5)

The line through (4) and (5) is $\frac{y - m \text{ cosec } A}{x - m \text{ cosec } A} = \frac{b \cot A - c \text{ cosec } A}{c \cot A - b \text{ cosec } A}$ .....(6)

(1) and (6) are perpendicular.

Miscellaneous.

206. *Proposed by H. E. Trefethen, Kent's Hill, Me.*

A bullet fired with a velocity of 1000 feet per second penetrates a block of wood to a depth of 12 inches. If it were fired through a plank of the same wood, two inches thick, what would be its velocity on emergence, assuming the resistance of the wood to the bullet to be constant?

I. Solution by W. B. Borgers, Grand Rapids, Mich.

Let w equal energy of ball, and v its velocity on emergence. Then $w = 1000^2 \times \frac{m}{2}$. Energy after passing through plank is $\frac{5}{6}\, w = \frac{vw^2}{2}$.

$\therefore\ v^2 = \frac{5}{6} \times 1000^2$, or $v = 912.87$ ft. per second.

II. Solution by I. L. Winckler, Cleveland, Ohio, and H. E. Trefethen, Kent's Hill, Me.

If s, t, f are the space, time, acceleration (negative in this problem), v the velocity of projection and u the ultimate velocity, the two equations (for a body moving under a constant force), $u=v-ft$ and $s=vt-ft^2/2$, give $2fs=v^2-u^2$....(1). If $u=0$, $s=1$ ft. and $v=1000$, (1) becomes $2f=1000000$.....(2); if $s=\frac{1}{6}$ ft. and $v=1000$, (1) becomes $2f=6000000-6u^2$ .....(3). From (2) and (3) $u=912.87$ ft. per second=the required velocity.

A Solution of Problem 14, by I. E. Kline, Blairstown, N. J.

If the bisectors of two angles of a triangle are equal, the triangle is isosceles.

In triangle ABC let m be the bisector of the angle A, n the bisector of angle B.

$$m = \frac{2}{b+c}\sqrt{b \cdot c \cdot s(s-a)}, \text{ and } n = \frac{2}{a+c}\sqrt{a \cdot c \cdot s(s-b)}.$$

See Durell's Plane Geometry, p. 213; also Failor's Plane Geometry, p. 176.

$$\therefore\ \frac{2}{b+c}\sqrt{b \cdot c \cdot s(s-a)} = \frac{2}{a+c}\sqrt{a \cdot c \cdot s(s-b)}, \text{ or } \frac{b(s-a)}{(b+c)^2} = \frac{a(s-b)}{(a+c)^2} \quad \ldots\ldots(1)$$

Replace s by $\frac{1}{2}(a+b+c)$, simplify, and factor, eq. (1) becomes $(b-a)$ $[c^2+c^2(b+a)+3abc+ab(b+a)]=0$. Since the second factor cannot be zero, $b-a=0$, and $a=b$.

NOTE BY EDITOR:

From $m^2 = bc - \frac{a^2bc}{(b+c)^2}$ we have $a=(b+c)\sqrt{\frac{bc-m^2}{bc}}$,

or $\sqrt{bc} : \sqrt{bc-m^2} = (b+c) : a$, which enables one to construct a triangle, having given two sides and the bisector of the included angle.

Again, from the same equation we have $bc = \frac{m^2}{1-\left(\frac{a}{b+c}\right)^2}$

which enables one to construct a triangle having given one side, the bisector of the opposite angle, and the sum of the other two sides.

Credit for Solutions Received.

Geometry 192. T. M. Blakslee, F. R. Ritzman, W. T. Brewer. (3)

Algebra 201. W. B. Borgers, W. L. Brown, H. G. McCann, E. M. Venables, I. L. Winckler, G. B. M. Zerr. (6)

Algebra 202. W. L. Brown, Orville Price, H. E. Trefethen, I. L. Winckler, G. B. M. Zerr. (5)

Algebra 203. W. B. Borgers, W. T. Brewer, W. L. Brown, J. A. Hardin, A. M. Harding, H. G. McCann, H. E. Trefethen (3 solutions), J. A. Whitted, I. L. Winckler, G. B. M. Zerr. (12)

Geometry 204. W. B. Borgers, W. L. Brown, J. A. Hardin, A. M. Harding, H. G. McCann, H. E. Trefethen, J. A. Whitted, I. L. Winckler, G. B. M. Zerr. (9)

Geometry 205. T. M. Blakslee (3 solutions), W. L. Brown, A. M. Harding, I. L. Winckler, G. B. M. Zerr. (7)

Miscellaneous 206. W. B. Borgers, W. L. Brown, A. M. Harding, I. L. Winckler, H. E. Trefethen (2 solutions), G. B. M. Zerr. (7)

Total number of solutions, 49.

PROBLEMS FOR SOLUTION.

Algebra.

212. *Selected.*

Show that the difference between any integer and its cube is divisible by 6.

213. *Proposed by H. E. Trefethen, Kent's Hill, Me.*

Each item of an account expressed in cents is some term from one or the other of the two series: 1, 7, 49, etc., or 2, 14, 98, etc. If the debit balance is $729.26, what are the several items on each side of the account. (A fine example in "Scales of Notation.")

Geometry.

214. *Proposed by C. M. Hebbert, Westerville, O.*

The alternate sides of an inscribed quadrilateral intersect in P and in Q. If tangents PR and QS be drawn, show that $PQ^2=PR^2+QS^2$.

215. *Proposed by Orville Price, Denver, Colo.*

Give a *direct* demonstration of the theorem, If in two triangles ABC and A′B′C′ $b=b'$, $c=c'$, $a>a'$, prove $A>A'$.

216. *Proposed by H. E. Trefethen, Kent's Hill, Me.*

Construct a triangle, given its altitude and the radii of the inscribed and circumscribed circles.

A review of the methods of the estimation of uranium and vanadium previously published was given at the Fortieth General meeting of the American Chemical Society by Edward DeMille Campbell and Charles E. Griffin. Experiments show that vanadium may be satisfactorily determined by reduction with sulphur dioxide and titration with permanganate, and vanadium and uranium together may be reduced by boiling with a spiral of heavy aluminum wire and titration with permanganate after the removal of the aluminum wire spiral and the addition of an excess of ferric sulphate. In the analysis of carnotite ore, after solution of the ore in nitric acid and evaporation with sulphuric acid, the vanadium and uranium are separated from iron by double precipitation of the latter with sodium carbonate in the presence of a little hydrogen peroxide. In the acidified solution the vanadium is first determined by reduction with sulphur dioxide to V_2O_4 and titration with standard permanganate, after which the vanadium is reduced by boiling with aluminum to V_2O_2 and the uranium to UO_2. After complete reduction of the uranium and vanadium, acidified ferric sulphate is added, and the solution is titrated with standard permanganate.

REAL APPLIED PROBLEMS IN ALGEBRA AND GEOMETRY.

COMMITTEE ON INVESTIGATION: JAMES F. MILLIS, *Chairman, Francis W. Parker School, Chicago;* JOS. V. COLLINS, *State Normal School, Stevens Point, Wis.;* C. I. PALMER, *Armour Institute of Technology, Chicago;* E. FISKE ALLEN, *Teachers College, New York;* A. A. DODD, *Manual Training High School, Kansas City, Mo.*

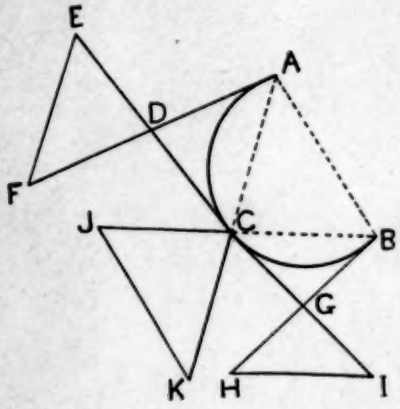
Teachers are invited to try out in the class room the problems that are here printed, with a view to determining their adaptability to the uses of secondary school pupils.

Copies of the problems printed in these columns up to November, 1909, may be obtained in pamphlet form for class room use by writing to Miss Mabel Sykes, Secretary of the Mathematics Section, Bowen High School, Chicago.

PROBLEMS.

By Miss Anna B. Ward, High School, Kokomo, Ind.

1. Given a round tower AB of a building. Required to find the shortest distance from A to B.



This problem was proposed by Frank Ulrich, student of the Kokomo High School. He gave the following construction, with proof:

I. Let C be any point on circumference.

II. From A and C draw straight lines intersecting at D, so that D is the mid-point of both lines. Draw EF connecting the two end points.

III. From B and C draw straight lines intersecting at G, so that G is the mid-point of both lines. Draw HI connecting the two end points.

IV. Draw JC equal to HI and making angle JCG equal to the supplement of angle HIG.

V. Draw CK equal to EF and making angle DCK equal to the supplement of angle FED.

VI. Draw JK.

Prove that JK equals the required distance AB.

Would this construction hold if C were taken anywhere outside of the circumference?

Can this construction be used for making the indirect measurement of the distance between any two objects separated by an obstacle?

By Jos. V. Collins, State Normal School, Stevens Point, Wis.

2. In a gymnastic exercise there are four movements, any one of which could follow any other. In how many different orders could they come?

3 In a gymnastic exercise of eight movements, one set of three have to come in a certain order, but the others could follow each other and the set of three in any order. In how many different orders could they all come?

4. On the average, the percentages of skim milk and buttermilk in milk are respectively 85% and 10%. Of the skim milk .2% and of the buttermilk .3% is fat. The wastage of fat from all the handling is 3%.

Now the fat in the finished butter, owing to the introduction of other matter, chiefly water and salt, is only 84% of the total weight. If b = number of pounds butter, and f = number of pounds fat in 100 lb. of milk, show that $b = 1.155\ (f—0.2)$.

5. Find the number of pounds of butter in 70 lb. milk which tests 4.4% fat.

6. Find the per cent of butter fat when 500 lb. of milk yield 19.7 lb. of butter.

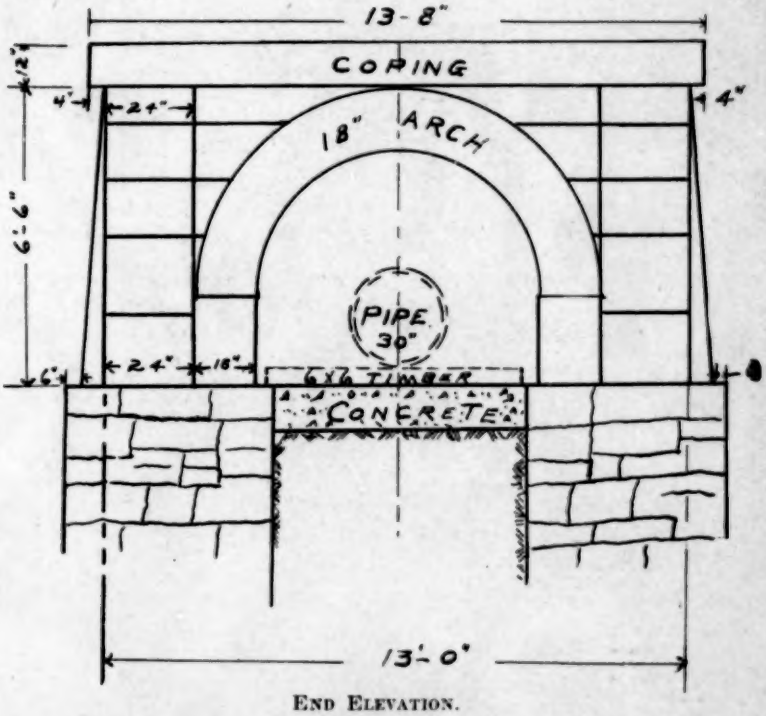
7. Show that the circumference of a circle can be found very approximately by taking three diameters along the blade (longer arm) of a steel square, and 15/16 of one diameter along the tongue (shorter arm), and measuring the hypotenuse.

8. Letting x and y denote the numbers of diameters on the arms of the steel square, as in the preceding exercise, find other values of x and y besides 3 and 15/16 that may be used to get the approximate value of the circumference of a circle.

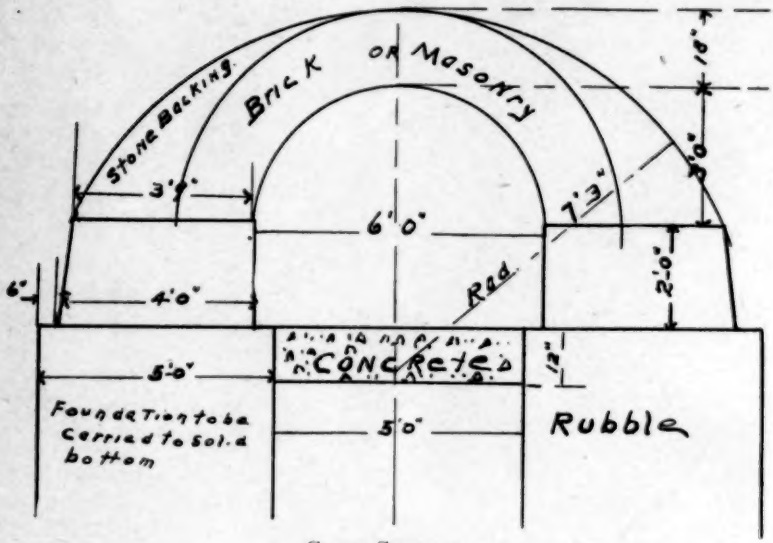
9. A farmer has a tract of land in the form of a trapezoid whose bases are 180 rods and 140 rods and altitude 115 rods. He desires to plant it in oats, wheat, and corn in strips parallel to the bases, the oats next to the longest side. The wheat acreage he wants to be 5 more than the oats, and the corn double that of the wheat. Where shall he set stakes on the altitude for the division lines?

By John H. Bortz, High School, Greensburg, Pa.

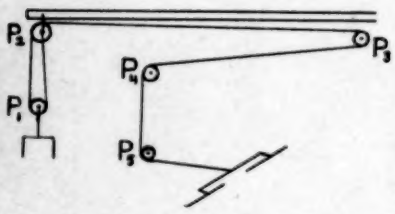
10. The accompanying figures represent the end elevation and cross section of an arch conduit for water mains. Length equals 77 ft. Grade equals 1 in. in 10 ft. A number of practical problems can be made from data.



END ELEVATION.



CROSS SECTION.



11. A farmer using a hay-hook has his pulleys arranged as in the diagram. If the friction at each of the pulleys P_1 and P_3 increases the tension 12%, and at each of the pulleys P_2, P_4, and P_5, 8%, and if the load on the hook is 500 lb., what tension is there on each section of the rope?

By James F. Millis, Francis W. Parker School, Chicago.

12. Two of my pupils this year have had need to compute the horse power of gasoline engines. One found the following formulae in *Motorcycle Illustrated*.

D=diameter of cylinder in inches, N=number of cylinders, S=length of stroke.

AUTHOR OF FORMULA.	FORMULA.
French Automobile Club	H. P. $= 0.45D^2N$.
Mr. Faroux	H. P. $= 0.121D^2 \cdot {}^4S^{0.6}$.
Another French Formula	H. P. $= 0.24D^{2.4}N$.
Mr. Thornycroft	H. P. $= \dfrac{D^2S^{0.75}N}{35{,}000}$.
Callender	H. P. $= 0.565D(D-1)N$.

These may be made the basis of a number of problems.

BIOLOGY SYLLABUS FOR FIRST YEAR OF HIGH SCHOOL.*

AUTUMN STUDIES.

EDITOR'S NOTE: There are so many plans being suggested at this time relative to the science work for the first year of the high school that the following syllabus is printed with the thought that it may prove of interest to all those who are interested in the general science problem, as well as to biologists.—ED.

Trees:

Introduce with general study of activities of tree.
Recognition of trees by leaves; compare leaves of other plants.
Work of leaves:
Transpiration; starch making.
Light relations and leaf movements.
Leaf arrangement and structure.
Insect enemies of trees.

Autumn Flowers:

Recognition and brief study of a few common fall flowers.

Spore Bearing Plants:

Mushrooms.
Parts and gross structure.
Reproduction: habitat.
Mode of obtaining food; saprophytism.
Edible and poisonous species; mushrooms growing.
Kinds.
Gill, tube and spine-bearing puff balls.
Other fungi.
Molds, mildews, rusts, smuts.
Injury done to fruits and vegetables.
Ferns and mosses.
General characteristics, habitat.

Gardening:

Pruning; cuttings.
Preparation of cuttings of grape, currant and gooseberry.
Bulbs.
Study of various kinds.
Time and method of planting, both for outdoor spring blooming and for indoor winter blooming.
Window gardening.
Outfit needed; window boxes or flower pots.
Plants adapted for house culture.
Care of plants: propagation of house plants.
Insect enemies of house plants.
Weeds of the garden and field.
Recognition of common weeds by seed and leaf; method of controlling weeds; state laws.

Insects:

Study of a typical insect, such as the grasshopper.
External structure, development, physiological processes.
Compare with beetle, bug, fly, moth.
Insects in their relation to man.
Relation to health.
Mosquitoes and malaria and yellow fever.
Flies and typhoid fever, tuberculosis and other diseases.

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*Prepared under the jurisdiction of the New Jersey Science Teachers' Association. Committee: Gilbert H. Trafton, chairman, Passaic High School; Julius Nelson, Rutgers College; Stella G. Streeter, Jersey City High School.

Insects injurious to crops and animals.
Enemies of garden produce.
Enemies of fruits.
Enemies of shade and forest trees.
Enemies of cereals.
Enemies of domestic animals.
Household pests.
Life history of these insects.
Methods of combating injurious insects.
Protecting birds, toads and other insectivorous animals.
Spraying.
(a) For insects with biting mouth parts.
(b) For insects with sucking mouth parts.
Beneficial insects.
Destroyers of injurious insects; parasitism.
Furnishing clothing and food.
Silk worm and allies, the silk worm moths of this country.
Honey bee; social life of insects.
Scavengers.
Miscellaneous uses.
Work of the U. S. Department of Agriculture through the Bureau of Entomology, and the State Agriculture Experiment Stations.
Other interesting insects.
Ants, wasps, galls and other insects homes.
Water insects.
Aquariums; animals and plants suitable for aquariums.
Kind of receptacles needed; care of aquarium.
General biology of insects.
Development.
Types of mouth parts.
Mode of locomotion; types of wings.
Adaptation to various habitats.
Protective resemblance and mimicry.
Characters of principal orders.
Other arthropods.
Structure and web-making habits of spiders; their relation to man.

WINTER STUDY.

Yeasts and Bacteria:
Yeast; use in causing bread to rise and in making alcohol; physiological effects of alcohol.
Bacteria.
Laboratory studies by means of cultures to show presence of bacteria in various places; to show their effects in causing souring of milk and decay; and to show methods of killing bacteria or retarding their action.
Form, size, multiplication, occurrence, spore formation.
Bacteria in the home.
Disease-producing bacteria.
Typhoid fever, tuberculosis, diphtheria, pneumonia, cholera, lockjaw.
Means by which bacteria are disseminated and enter the body.
Methods used in curing diseases.
Anti-toxines, inoculation.
Methods of preventing diseases.
Vaccination.
Care of water and ice supply, pasteurization of milk; disposal of refuse and sewerage.

Isolation and other methods of preventing dissemination of bacteria.
Prevention and cure of tuberculosis.
Wholesome food and fresh air. Hygiene of respiration, ventilation and heating; window tents. Dangers of dust.
Beneficial bacteria.
Nitrogen-fixing bacteria.
Bacteria as scavengers.
Bacteria in the arts and the dairy.
History of the development of bacteriology: Pasteur, Koch, von Behring.
Other one-celled organisms.
Cellular structure of plants and animals.

Winter Studies of Trees:
External structure and markings of twigs.
Buds; their parts, structure and position.
Recognition of trees from winter characteristics.
Functions of stems.
Structure in cross section; sections found in furniture, floors, etc.

Forestry:
Value of forests; need of preservation.
Source of lumber, fuel, paper, turpentine, cork.
Protective cover; regulating water supply of streams, as a means of preventing floods and waste of soils, and as a means of furthering the use of streams for irrigation, water-power and navigation.
Effect of removing forests.
Esthetic value.
History of forestry in United States; present distribution of forests.
Need of national reservations in the White and Appalachian Mountains.
Proper methods of caring for forests.
Enemies of forests; insects, fungi, fires.
United States Forest Service.

Fisheries:
Oyster, clam, scallop, lobster, crab, shrimp.
Fishes.
Characters, activities, respiration.
Fish propagation.
Aquatic mammals.
Protection of seals.

Mammals:
Domesticated mammals.
Horse, sheep, hog, cow; dairying.
Breeding by selection.
Game mammals.
Deer, fox, beaver, buffalo.
Injurious mammals.
Mouse, rat, ground squirrel, pouched gopher; natural enemies.

SPRING STUDY.

Seeds:
Structure and types.
Nutrients stored in seeds.
Seeds used as foods: cereals, peas, beans, nuts, chocolate.
General study of foods.
Relative value of foods, dietaries, food economy; cooking; new school of physiologists, Chittenden, Fisher, Fletcher.
Adulteration of foods. United States Division of Foods.
Hygiene of digestion.
Digestion of starch by plants and animals.

Testing seeds for purity and power of germination.
Conditions of moisture and temperature needed for germination.
Depth and time of planting various seeds.
Preparation of soil for planting and subsequent culture.
Development of seedling.
Change in parts of embryo.
Methods of breaking soil.
Response of root and stem to gravity and light.
Respiration in plants; comparison with animals.

The Use of the Home Grounds:
Possibilities of small yards.
Ornamentation of grounds.
Shrubs, vines.
The flower garden.
The vegetable garden.
The fruit garden.
Methods of propagating fruits; pruning.
Plant improvement by crossing and selection.
Enemies of the garden; spraying.
Canning fruits and vegetables.
Bee keeping.
Poultry keeping.

Roots and Soils.
Work of the root.
Response to moisture.
Structure; root hairs.
Soil relations.
Types and composition of soils.
Water capacity of various soils.
Treatment of soil for raising plants.
Fertilization, tillage, drainage, irrigation.
Effect of earthworms on soil; studies made by Darwin.

Flowers:
Structure and use of the parts.
Purpose of the flower.
Devices for preventing self-pollination.
Devices for securing cross-pollination.
Adaptations to insect pollination.
Mouth parts of insects concerned.
Adaptations to wind pollination.
Pollination by humming-birds.
Fertilization; result of this process.
Studies of a series of flowers to illustrate various habitats, and types of plants.
Flowers of the wood, of the marsh, of the roadside, or weeds, of shrubs, of shade and forest trees, of fruit trees of the vegetable garden, of the flower garden, of bulbous plants, of vines.
Classification into families; families of economic importance.
Flower calendar; recognition of both wild and cultivated flowers.
Methods of collecting and preserving flowers, leaves, and ferns.

Insects:
Pollinators of flowers of fruit trees and other plants.
Value of bees in the orchard; butterflies and moths.
Some of the work suggested in the fall outline can be taken up in the spring with equal or perhaps better advantage.

Birds:
Their value to man.
As destroyers of weed seeds, injurious insects and mammals, scavengers; their esthetic value.
Work of the United States Department of Agriculture through the Bureau of Biological Survey.
Bird enemies; the English sparrow, a national problem.
Bird protection.
Methods of attracting birds around houses.
Migration; songs; nesting habits; care of young nestlings.
Bird calendar; recognition of common birds.
Adaptation of bill and feet to various modes of life.
Amphibians:
Habits and activities; hibernation.
Economic importance.
Recognition of common toads, frogs and salamanders.
Development.
Summary and Review:
Similarity of life processes in plants and animals.
Fundamental differences between plants and animals.
General classification of plants and animals.
Historical development of botany and zoölogy; biography.
Observations During Summer Vacation:
Seaside studies.
Algæ, jelly fish, sponges, clams and conchs.
Worms, sand fleas, sea anemone, sea fowl, fishes.
Mountain studies.
Trees, flowers, birds, ferns, mosses, insects.
Farm studies.
Rodents, insects, birds, flowers, rabbits, vegetables, crops, grasses.
Garden studies.
Slugs, insects, worms, birds, flowers, vegetables, weeds.
Forest ramples.
Insects, birds, trees, ferns, mushrooms.
Fishing and camping excursions.
Amphibians, crustaceans, aquatic insects, pond life, water and marsh plants, snails, mussels, fishes, water birds.
Home studies.
Flower, vegetable and fruit garden; planting home grounds.
Poultry, bees, attracting birds.
Studies with the camera.

BIOLOGY TABLES.

By Conrad E. Tharaldsen, State Normal School, Mayville, N. D.

Tables such as these described below were made by our manual training department and installed in the laboratory. They are neat, cheap, and efficient. The total cost of material was about four dollars per table. The material was well-seasoned white pine. The lower portion of the tables was varnished over a filler, with no stain, thus preserving the natural color of the wood. The top was finished with an aniline black chemical proof stain such as that described on page 157 of the February, 1908, number of School Science and Mathematics. The tables represent a very pleasing appearance with their light base and black top. The stain is not affected by the ordinary chemicals used in the laboratory and is very easily kept clean.

SCIENCE QUESTIONS.

FRANKLIN T. JONES,
University School, Cleveland, Ohio.

Readers of SCHOOL SCIENCE *are invited to propose questions for solution—scientific or pedagogical—and to answer the questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.*

Questions and Problems for Solution.

27. *Proposed by J. Hawley Aiken, Saratoga Springs, N. Y.*

A river 40 ft. wide is dammed. After the water has adjusted itself, it is found to be 10 ft. deeper on the upper side. Find the unbalanced pressure against the dam.

28. *Proposed by A. Haven Smith, Seattle, Wash.*

Why are there an odd number of segments in the commutators of some dynamos?

29. *Proposed by W. B. Hughes, the Wellman-Seaver-Morgan Engineering Co., Cleveland, Ohio.*

If the density of a gas is .93, and the density of air is 1, what force is required to drive the gas 30 feet down against atmospheric pressure?
(This is a practical problem met in gas producer operation.)

30. *From a Harvard examination paper.* (An optional problem.)

10 grams of the chloride of a certain univalent element are found to contain 60.6 per cent of chlorine. If the atomic weight of chlorine is 35.5, what is the atomic weight of the other element?

31. *Proposed by A. Haven Smith, Seattle, Wash.*

Is there a *simple* proof for the fact that, in an electrodynamometer, the angle through which the coil moves is directly proportional to the square of the current?

Solutions.

21. *From an examination paper of the International Y. M. C. A.*

A grocer has a platform balance the ratio of whose arms is 9 to 10. If he sells 20 pounds of merchandise to one man, weighing it on the right hand pan, and 20 pounds to another man, weighing it on the left hand pan, what per cent does he gain or lose by the two transactions?

Solution by G. B. M. Zerr.

For 20 pounds on 10 arm, weight $= \frac{20\times10}{9} = 22\frac{2}{9}$

For 20 pounds on 9 arm, weight $= \frac{20\times9}{10} = 18$

$22\frac{2}{9} + 18 = 40\frac{2}{9}$ pounds or $\frac{2}{9}$ pounds he loses.

$\frac{2}{9} \div 40 = \frac{1}{180}$, $\frac{1}{180}$ of $100\% = \frac{5}{9}\%$ he loses.

Also solved by A. Haven Smith, E. B. Benger, J. Hawley Aiken.

22. *From an examination paper of East High School, Cleveland.*

A and B carry a fish weighing 54 lbs. slung between them from the middle of a 10-foot oar. One end of the oar rests on A's shoulder, but the other end is pushed one foot beyond B's shoulder. What part of the weight does each carry?

Solution by J. Hawley Aiken, Saratoga Springs, N. Y.

The moments about A's shoulder are 5x54 down, and $9x$ up.

x = pressure on B's shoulder

$9x = 5x54 \quad x = 30$ weight on B's shoulder.

In like manner the moments about B's shoulder:

x=pressure on A's shoulder

$9x = 4x54 \quad x = 24$ weight on A's shoulder.

Solutions were also received from E. B. Benger, A. Haven Smith, G. B. M. Zerr, William H. Fisher.

23. *From an examination paper of East High School, Minneapolis.*

How much heat will a 16-candle power light give out in one hour?

Solution by A. Haven Smith, Seattle, Wash.

Heat $= C^2R \times t \times .24$

$= (.5)^2\ (220)\ (3600)\ (.24) = 47.520$ calories.

Note by E. B. Benger:—The assumption is that, although some of the energy immediately appears as light, eventually all of the energy is transformed to heat.

Note by G. B. M. Zerr:—This is enough heat to raise the temperature of a kilogram of water 47.52° C. It is equal to 188.56 B. T. U.

A solution was also received from J. Hawley Aiken.

24. *From an examination paper of the University of Oxford.*

A half-ounce bullet is fired with a velocity of 1,400 feet per second from a gun weighing 7 lbs. Find the velocity in feet per second with which the gun begins to recoil, and the mean force in pounds weight that must be exerted to bring it to rest in 4 inches.

Solution by E. B. Benger, Louisville, Ky.

Since the momenta of the bullet and gun are equal in magnitude

$$7v = \frac{1}{32} \cdot 1400, \text{ whence } v = 6.26 \text{ ft. sec.}$$

$$\text{And } E = \frac{mv^2}{64.2} = \frac{7 \cdot 6.26^2}{64.2} = 4.3 = \text{energy of recoil.}$$

Also $W = Fs$, $\therefore 4.3 = F\,{}^4/_{12}$ or $F = 12.9$ lbs.

Solutions are also acknowledged from A. H. Smith, J. H. Aiken, and G. B. M. Zerr.

A solution of problem 18 by Brian S. Brown of Thomaston, Ga., has not been previously acknowledged.

EXAMINATION QUESTIONS.

About a year ago the Editor of the Science Questions Department addressed individual letters with return envelopes to about 400 schools asking for examination questions in the sciences. About 100 replies were received. The questions thus collected were very valuable and interesting but the expense was too great to permit such a collection every year.

Readers of SCHOOL SCIENCE AND MATHEMATICS will confer a great favor by sending copies of tests or examination questions to Franklin T. Jones, University School, Cleveland, Ohio.

At the University of Pennsylvania hereafter the chairman of each department of instruction will be elected annually by the department.

For the year 1910-1911, Professor George Egbert Fisher has been chosen chairman of the Department of Mathematics in the Graduate School, and Professor Isaac J. Schwatt chairman of the Mathematical Department in college.

TWO BOOKS ON NON-EUCLIDEAN GEOMETRY.

By Richard Hayes Devana.

I lately happened upon an extraordinary little series of mathematical booklets—known scarcely at all, I believe, to the commonality of secondary teachers, and bearing the imprimatur of no authoritative publisher. When an attempt was made to borrow two of these from the Barton-Ticknor special library of the Boston Public Library, the response was that such books were not loaned to the general (*i. e.* unidentified) public—only to Harvard professors (!) and a few others. But the would-be borrower's zeal was equal to the occasion, and soon, as one of the few others, he carried home in triumph volumes III and IV of the Neomonic Series, published at the Neomon, Austin, Texas, 1896-1897. Then—silence "upon a peak in Darien." The Neomon seems to have vanished from the face of the earth; efforts to secure copies through the "trade" failed. The books in question are *The Science Absolute of Space*, by John Bolyai, translated from the Latin by George Bruce Halsted, and *Geometrical Researches on the Theory of Parallels* by Nicholaus Lobatschewsky, translated from the Russian by George Bruce Halsted. Clearly well known in expert circles, these translations have been strangely withheld from teachers of humbler grade. But the teacher weary of the slightly treacherous geometry of the leading book firms and bewildered by the whir of magazine-institute-convention discussion, will find these unostentatious little books and read from cover to cover, undeterred by the somewhat undisciplined and at times slashing English, will have his reward in a wholly new and joyous insight. The charm of the books is the charm of original documents. In the 155 pages that make the total of both, the reader will find the source of much that he may have had at second hand. Tucked away in thin prefaces and appendices are ideas that might, and apparently have leavened swollen volumes.

I should like to give one excerpt: "Euclid stated his assumptions with the most painstaking candor, and would have smiled at the suggestion that he claimed for his conclusions any other truth than perfect deduction from assumed hypotheses. In favor of the external reality or truth of these assumptions he said no word." We may be pardoned, I think, for reading that with a little resentment. If that was known thirteen years ago, even in America, why were we not told sooner? Why was it allowed to remain hidden in a practically inaccessible publication, the exclusive possession of the learned, while so many of us until very recently, and some of us still, remained "overawed by the conviction of the absolute necessity of Euclid's system?"*

*Translator's Instruction, "Science Absolute of Space."

Boston, Mass.

Dr. George Bruce Halsted, head of the department of mathematics of the Colorado State Normal School at Greeley, and a frequent contributor to this journal, has been selected by the Century Dictionary people to revise the mathematical terms and words for the new volumes of this work which are about to be published.

A COLOR SCHEME FOR FIGURES IN SOLID GEOMETRY.

By Miss M. C. Spencer,
Tulane University, New Orleans.

Difficulty in making pupils see more than one plane in a black and white figure is experienced, without doubt, by every teacher of solid geometry. It is always evident in the first lessons that through the study of plane geometry they have acquired the habit of seeing all lines in the same plane, and that to their untrained eyes there is nothing but a hopeless confusion of intersecting lines. The first thing necessary then is to train the class to see in this seeming confusion of lines two or more planes as the case may be and to decide whether a line lies in one or more than one plane, or perhaps in none at all.

With the hope of accomplishing this necessary but difficult first step devices of various sorts have been offered, such as shaded figures, photographs, colored planes and models. Of these some are valuable but take too much time or too much skill; others cannot be done at all by the pupils, a most serious objection since a crude figure drawn by the pupil has more training value than the most skillfully executed drawing of textbook or teacher. Colored planes bring out well the solidity of the figures and help greatly in distinguishing one plane from another. The objection, however, to coloring the entire plane is that it takes a great deal of time besides making almost invisible at a short distance lines in the planes which are essential to the proof.

The color scheme here given is one that has seemed to overcome a few of these objections and has been tried in class work for several years with some success. As will be found this color scheme is best adapted to Book VI and cannot be used for the other books. This, however, does not lessen its value, for the test of seeing the three dimensions of space must come in studying this book; and if then understood the rest follows with comparative ease.

The scheme is as follows: (1) a color is used to outline the portion of each plane used; (2) all lines in a plane, provided they are not intersections of the plane with another are drawn in the color chosen for outlining that plane; (3) all lines common to two or more planes are drawn white on the blackboard and black on paper.

Doubtless the objection will at once be offered that nearly every line in all figures of solid geometry could be thought of as an intersection. This is true enough but only the planes needed in the proof should be emphasized by having a distinguishing color. In fact, the same figure can be colored in more than one way and, for this reason may be used to prove an entirely different theorem. Often too, in this scheme a plane implicitly used in the proof can be drawn with its characteristic color, thereby giving clearness to the proof. The color prevents confusion which otherwise might arise because of the addition of more lines to the figure.

One important advantage of this color scheme is that these figures are as quickly and easily drawn with the colored pencils or chalk by the pupils themselves as are the ordinary black and white figures. Each figure can be drawn by all, giving by this means the practice in drawing and seeing, which makes the impression more complete and more lasting. Another is, that one comes naturally to think of all lines in the same plane as having the same color and this enables the eye to serve as guide to the brain. Besides the help to the pupils there is another of great importance to the teacher: this method of drawing the figures is a test of the pupils' power to analyze the conditions of the problem. In fact, there is no getting around it; for by the color used they must declare exactly where they think the lines are.

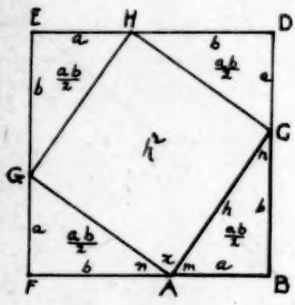
THE PYTHAGOREAN THEOREM.

By Wm. Scott,

Aliquippa, Pa.

The following, I believe, is a new demonstration of the Pythagorean theorem.

Let ABC be a right triangle, AB=a and BC=b. Produce the legs as shown, making CD=a and AF=b.



Complete the square BDEF. Lay off the legs of the triangle on the sides of the square as shown, and join the points A, C, H, and G, forming equal triangles, the area of each one being $\frac{ab}{2}$

Let x equal the angle GAC, and m and n equal the acute angles of the given triangle.

Then $x+m+n=180°$.

But $m+n=90°$.

Hence $x=90°$, and the figure ACHG is a square whose area is h^2.

$ABEF=a^2+2ab+b^2=h^2+2ab$

Hence $a^2+b^2=h^2$.

(This is an interesting variation of one of the hundred proofs published in the *American Mathematical Monthly*, 1896-9. New and Old Proofs of the Pythagorean Theorem, by Yanney and Calderhead—*Math. Ed.*)

A SIMPLE INDUCTION EXPERIMENT WITH THE ELECTRIC WHIRL.

By Herbert W. Harmon,

Grove City College, Grove City, Pa.

For several years I have noticed that the electric whirl placed on the base of the Toepler-Holtz electrical machine a short distance in front of the revolving plate when the machine is in action rotates as rapidly as if kept charged in the usual way, and have used it for another illustration of charging by induction. Not having seen the experiment described in any of the text-books, I mention it in the interest of School Science and Mathematics readers. In the dark the whirl appears as a circular glow of light. The explanation probably is that the buttons and revolving glass plate being charged say (—) induces (+) on the near end of the whirling arms and (—) on the far end, the sharp points as usual discharge these oppositely induced charges, the reaction of the streaming off charged air particles causing the rotation. The charged Leyden jars add their inductive action to the above.

Our students in the Study of the Toepler-Holtz Elec. Mach. Ex. are using three independent methods in determining the kind of electrification of each of the parts of the machine. They are:

(a) Proof-plane—Gold-leaf electroscope.

(b) Direction of deflection of sensitive galvanometer.

(c) The (+) brush discharge in the dark.

HEAVY DRAINS ON NATION'S FORESTS.

"The total yearly drain upon our forests, not counting losses from fires, storms, and insects, is some twenty billion cubic feet," says R. S. Kellogg, assistant forester in charge of the office of forest statistics, in a publication just issued by the Forest Service on "The Timber Supply of the United States."

"Our present forest area of 550 million acres may be roughly estimated to consist of 200 million acres of mature forests, in which the annual growth is balanced by death and decay, of 250 million acres partially cut or burned over, on which, with reasonable care, there is sufficient young growth to produce in the course of time a merchantable, but not a full crop of timber, and 100 million acres of more severely cut and burned over forests, on which there is not sufficient young growth to produce another crop of much value.

"Taken as a whole, the annual growth of our forests under these conditions does not exceed twelve cubic feet per acre, a total of less than seven billion cubic feet. That is, we are cutting our forests three times as fast as they are growing. There is menace in the continuance of such conditions. While we might never reach absolute timber exhaustion, the unrestricted exploitation of our forests in the past has already had serious effects, and it will have much worse if it is allowed to continue unchecked.

"White pine, for instance, which was once considered inexhaustible, has fallen off seventy per cent in cut since 1890, and more than forty-five per cent since 1900. The cut of oak, our most valuable hardwood lumber, has decreased sixteen per cent since 1900, and that of yellow poplar twenty-two per cent. The same story will be told of other woods if they are not conserved.

"The fact that timber has been cheap and abundant has made us careless of its production and reckless in its use. We take 250 cubic feet of wood per capita annually from our forests, while Germany uses only thirty-seven cubic feet, and France but twenty-five. On the other hand, Germany, who has learned her lesson, makes her state forests produce an average of forty-eight cubic feet of wood per acre. We have as fast-growing species as Germany, or faster, and as good or better forest soil if we protect it.

"The necessity for more farm land may eventually reduce our total forest area to 100 million acres less than it is at present. It is entirely possible, however, to produce on 450 million acres as much wood as a population much greater than we have now will really need if all the forest land is brought to its highest producing capacity and if the product is economically and completely utilized. But to reach the necessary condition of equilibrium between timber production and consumption will take many years of vigorous effort by individual forest owners, by the States, and by the National Government. None of them can solve the problem alone; all must work together."—*Forest Service.*

REORGANIZATION OF THE FIRM OF D. C. HEATH & CO.

Messrs. W. E. Pulsifer, W. H. Ives and W. S. Smyth have recently purchased from the heirs of the late D. C. Heath their entire holdings of the stock of the corporation well known in the publishing world as D. C. Heath & Company. The annual meeting of the corporation was held on May 2nd, and an entire reorganization of the business took place at that time. The following officers were elected: W. E. Pulsifer, President; W. H. Ives, Vice-President; C. H. Ames, Secretary; W. S. Smyth, Treasurer. The Board of Directors will consist of the officers above named, together with the following gentlemen: J. C. Simpson, Boston; I. A. Van Houten, New York; F. F. Hummel, Chicago.

Messrs. Pulsifer, Smyth, Ives, Ames and Simpson have been identified with the Heath business for a long time and were associated with the late D. C. Heath in the building up of the business. Mr. Hummel has been for a number of years the Chicago manager of the Macmillan Company. His record in that position has been an enviable one, and his promotion to a more important post is a well-earned recognition of his experience and ability in the business. Mr. Hummel will take charge of the Chicago office of D. C. Heath & Company, thus filling the vacancy created by the withdrawal of Mr. Ives who goes to the home office of the company to act as vice-president of the new organization, and to take personal charge of the publication work.

Mr. Van Houten is one of the best known book men in the East. For many years he has represented the American Book Company in New Jersey. He now becomes the general manager of the New York office of D. C. Heath & Company, and will supervise the agency work of the company in the New York territory.

Mr. Simpson, who has for a long time been connected with the New England office of the Heath Company, becomes the general manager of that office and thus takes charge of the field where he has spent many years of active work and where he is well known to the educational public.

A COMMUNICATION.

EDITOR SCHOOL SCIENCE AND MATHEMATICS:

On Page 491 of SCHOOL SCIENCE AND MATHEMATICS, May, 1909, the question is asked: "A ball bounds a finite distance, and, in each succeeding bound, rebounds one half the distance of the preceding bound. Will it ever come to rest?"

Contradictory answers are published from Mr. Bjorkland and Mr. Korns, one saying that it would come to rest in $3.1414t$ seconds, where t is the time required for the first bound, while the other says it would continue forever, though its motion would soon become negligible.

The discrepancy lies in the fact that although the movements through the air from the ground and back would take place in shorter and shorter times, so as to be limited as Mr. Bjorkland says, the time the ball takes to undergo distortion and restitution in contact with the ground is constant, like that of any simple harmonic motion, and must be added to the time required for each rebound. Thus, although the total amount of time the ball is away from the ground is limited, yet this time is divided up into periods separated by finite intervals, so that it does not cease bounding after that length of time.

WM. B. BORGERS.

SERIOUS INSECT PEST DESTROYING WHITE BIRCHES.

The ravages of a small insect, the bronze birch borer, are reported from several counties in Wisconsin in letters received by Pofessor J. G. Sanders, entomologist of the College of Agriculture of the University of Wisconsin. This insect destroys the white birch, and since it is probably distributed in many sections that have not been reported, owners of white birch trees are urged to examine them for this deadly pest. Birches in forests are not so generally infested, since woodpeckers hold the insects in check more than in ornamental plantings.

"Infested trees are indicated by dying tops and upper branches, which usually bear the leaves of the past season," states Professor Sanders. "Such a tree should be examined for the winding galleries in the wood beneath the bark and for ridge-like swellings on the younger green branches made by the white larva of this beetle. The larva matures in late spring and emerges from the tree as a small bronze colored beetle, cylindrical in form, with a blunt head and tapered body.

"To control the pest, infected trees should be cut and burned before May 1. Trees must be completely destroyed, regardless of their value, if infected, to insure the killing of the larva and young beetles before they leave the tree to infect other trees. It is useless to cut off and burn the dead portions of the tree, since the beetles have already abandoned them for new, green wood."

The experiment station is collecting data concerning the distribution and injury by this pest, and Professor Sanders is requesting reports on the extent of infestation, and furnishing particulars on how to control the pest.

THE SKETCHING OF APPARATUS.

No attempt should be made at perspective. The aim should be (1) to indicate whether given parts of the apparatus are open or closed; (2) to show the nature of the materials used and the effect of the purifying and drying chemicals which should be indicated twice (*a*) where the process is accomplished, (*b*) in the delivery tube succeeding; (3) to show the level of liquids particularly with reference to delivery tubes and thistle tubes.

The idea is that one reads a diagram more easily and quickly than written matter and that simplification of the drawing allows space for indicating clearly the details of the process. Jessie Caplin, West High School, Minneapolis, Minn.

The Junior Wireless Club is making a strong protest against bills that are now before Congress aiming to restrict amateur work in wireless telegraphy. Particularly objectionable to them is the proposed annual fee of $100, to be exacted from all wireless stations. As there are between 40,000 and 50,000 boys in the country with their own wireless equipments, this virtually represents a tax of between four and five million dollars. Of course, very few boys could pay a $100 fee, and the result would be that practically all amateurs would be eliminated from wireless experimentation. It does not seem as though this would be advisable, because many of the improvements in wireless telegraphy have been the work of amateurs.

Ground mica is used in some quantity, the coarser grades in mica bronzes and paints and also as an absorbent for explosives. Ground mica also forms an ingredient in some heavy lubricants. The finest ground mica or mica flour finds a considerable market with the manufacturers of high grade wall papers, the luster obtained by the use of the muscovite dust having the advantage of both permanency and brilliancy.

ARTICLES IN CURRENT MAGAZINES.

American Naturalist for May: "A Review of Some Recent Criticisms of the Restoration of Sauropod Dinosaurs," J. W. Holland; "Anatomical Characters in the Evolution of Pinus," Irving W. Bailey; "Facts about the Pearl Lobster," Francis H. Herrick.

Astrophysical Journal for April: "On the Origin of Binary Stars," Henry N. Russell; "Observations on the Aurora, Made at the Yerkes Observatory," E. E. Barnard; "Star Colors: A Study in Physiological Optics," Louis Bell; "The Absorption of Star Light Considered with Relation to the Galaxy," George C. Comstock.

Bird-Lore for March-April: "President Roosevelt's List of Birds Seen in the White House Grounds and about Washington;" "The Pileated Woodpecker," Ernest W. Vickers; "A New Departure for the Redwing," Howard H. Cleaver; "Notes on Water Birds in Forest Park, St. Louis," H. C. Williams and N. de W. Betts.

Nature-Study Review for April: "Agricultural Nature-Study as Exemplified in the School Garden," F. L. Charles; "School Gardens in Elizabeth City County, Va.," Ellen Guy Lindsay; "School Gardens in Louisville, Ky.," Emilie Yunker; "The Educational Museum of the St. Louis Public Schools;" "A Remarkable Observation on Bird Behavior," Nina L. Sweetland; "Nature-Study and Vocational Training," John D. Haney.

Physical Review for April: "Scattered Light in Spectrophotometry and a New Form of Spectrophotometer," Herbert E. Ives; "The Rectifying Effect in the Point and Plane Discharge," R. F. Earhart and Chas. H. Lake; "An Apparatus for Measuring Sound," F. R. Watson; "Some Electrical Properties of Selenium. II. The Recovery from Excitation by X-Rays," Louise S. McDowell; "Typical Cases of Secondary Radiation Excited by Uranium-X," W. B. Huff; "An Automatic Circular Dividing Engine," W. R. Stamper and Elmer E. Hall; "The Coefficient of Expansion of Nickel near its Critical Temperature," Walter F. Colby; "Note on the Relation between the Temperature and the Resistance of Nickel," C. F. Marvin.

Popular Astronomy for May: "The Real and Apparent Positions of Halley's Comet During its Period of Greatest Importance," Joseph Wilczewski; "The Orbits of Meteorites," William H. Pickering; "Planet Orbits. IV," Thomas C. Ryan; "Halley's Comet and the Church," John C. Dean; "A Great Open-air Telescope," S. A. Mitchell.

School Review for May: "Science and Education," Richard C. Maclaurin; "The Norwich Tests, 1862-1909," Henry A. Tirrell; "Coöperation of Business Men of Pittsburg with the Commercial Department of Its High School," Edward Rynearson; "The Advantages of Limited Sex Segregation in the High School," J. E. Armstrong.

Science for April 22: "The Choice of Medicine as a Profession," Harold Williams; "An International Coöperative Investigation on Electrical Standards," Dr. Edward B. Rosa; "Federal Expenditures for the Conservation of the National Health," W. N. Berg. For April 29: "Botanical Gardens," Dr. N. L. Britton, W. F. Ganong, Duncan S. Johnson; "The Relation of Applied Science to Education," Cyril G. Hopkins. For May 6: "The Administration of Botanical Gardens," William Trelease; "Statistics of Foreign Universities," Rudolf Tombo.

Zeitschrift für den Physikalischen and Chemischen Unterricht for March: "Glossen zur Behandlung der elektrischen Einheiten im Unterricht," V. Strouhal; "Gasvolumetrische Schulversuche," W. Bahrdt; "Zur Demonstration von Kondensatorschwingungen," A. Strobel; "Akustische Versuche mit Glasröhren," A. Stroman; "Uber eine einfache Quecksilberluftpumpe ohne Hähne, Schliffe und Barometerröhren nach dem Steigerohrprinzip," H. Bauer; "Zum Kräftsparallelogramm-Versuch," E. Schulze.

Rock gypsum occurs in the form of beds, frequently closely associated with beds of rock salt, and almost always interstratified with thin beds of limestone and thicker beds of red shales. Such gypsum beds may vary greatly in extent as well as in thickness. Beds now worked in different American localities, for example, vary from 6 ft. to 60 ft. in thickness. The gypsum occurring in the beds frequently contains a considerable percentage of impurities.

REPORT OF THE NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS.

The thirty-eighth meeting of the association was held Saturday, April 16, 1910, at the Harvard Medical School, Boston, Massachusetts. The meeting opened with the election of new members and the reports of various standing committees. Professor L. C. Newell, Chairman of the Committee on Current Events, spoke of Polonium, Purple Dye, Titanium, Obituaries of Gibbs and Kohlrausch, and publications obtainable on request. Mr. A. M. Butler, Chairman of the Committee on New Apparatus, showed a new electrolysis and ionization apparatus and described an ingenious device for utilizing the sun's heat rays in chemistry work. Under the direction of Mr. G. A. Cowen, Chairman of the Committee on New Books, Mr. L. G. Smith reviewed "Stock-Stachler Praktikum der quantitativen anorganischen Analyse," and Mr. W. Segerblom reviewed Van Nostrand's "Chemical Annual, 1909." Dr. L. C. Newell also spoke briefly of "The Romance of Modern Chemistry," by J. F. Phillips, and "The Story of Oil," by W. S. Tower. Under new business Mr. Segerblom called attention to the twenty-page report of the American Federation of the Teachers of the Mathematical and Natural Sciences in SCHOOL SCIENCE AND MATHEMATICS for April and to the appointment by the Federation of a committee to carry on the work suggested by the New England Association of Chemistry teachers.

The principal address of the day was on "The Function of Enzymes in the Chemistry of Life," by A. W. Peters, Ph.D., of the Harvard Medical School. The Enzymes were described from the standpoint of their catalytic, their specific, and especially their reversible and synthetic modes of action Enzyme action is largely analytical by means of hydrolysis. When enzymes function in an integrative way, i. e., are reversible, they fail to store in quantity the energy which could be obtained from the environment. The synthesis of carbohydrates by the organism and by laboratory methods were compared. The latter involve toxic and corrosive chemicals, violent physical conditions, and an uneconomic yield. The theories were described which attempt to account for the reduction of carbon dioxide to carbon monoxide by the plant and for the formation of the first aldehyde and of sugar. In the present state of our knowledge we are not able to account satisfactorily for the natural syntheses as reversible enzyme actions.

This was followed by a short address by C. A. Scott, Ph.D., of the Boston Normal School on the "Psychology of Science Teaching." He emphasized the development of the reasoning process in the pupils. His address was followed by a short discussion.

The half hour remaining before lunch was devoted to a visit to the laboratories of the Harvard Medical School.

The afternoon session was opened by Mr. T. W. Carpenter, chemist at the Carnegie Nutrition Laboratory, Boston, Mass., by a description of the Carnegie Nutrition Laboratory and its special apparatus for measuring respiration products and for measuring the expenditure of energy by the subject. This was followed by an hour's inspection of this laboratory and of its interesting apparatus in actual operation.

In accordance with the recommendation in the report of the Committee on Publications of the American Federation of Teachers of the Mathematical and Natural Sciences the New England Association of Chemistry Teachers appointed an editorial representative who has compiled the above report.

WILHELM SEGERBLOM.

MATHEMATICAL AND PHYSICAL SECTION OF THE ONTARIO EDUCATIONAL ASSOCIATION.

The Mathematical and Physical Section of the Ontario Educational Association held its annual meeting in the main building of the University of Toronto March 29-30, 1910. The President, Mr. J. D. Dickson, of Niagara Falls, presided at all the sessions and opened the meeting by an address on "Simple Graphs."

The following papers were read: "The Development of the Notions and Laws of Arithmetic," by W. J. Longheed of Toronto; "Some Mistakes in the Teaching of Arithmetic," by E. T. Seaton of Hamilton Normal School; "Methods in Teaching Constructive Geometry," by W. W. Nichol of Ottawa; "Modern Geometry," by Mr. A. Kennedy.

The last session was a joint meeting with the Natural Science Section at which Prof. J. C. McLennon of the University of Toronto illustrated experimentally some of the work which he thought should be added to the physics course for secondary schools.

The following officers were elected for 1910-11: Honorary President, J. D. Dickson, Niagara Falls Collegiate Institute; President, John Elliott, Bowmanville High School; Vice-President, W. J. Patterson, Western University; Secretary-Treasurer, T. Kennedy, Oakwood High School, Toronto; Councillors: J. T. Crawford, Hamilton Collegiate Institute; H. S. Robertson, Stratford Normal School; W. J. Longheed, Jarvis Street Coll. Inst., Toronto; J. Davison, Guelph Coll. Inst.; G. H. Hogarth, Whitby High School.

A communication from the Mathematical Association, London, England, regarding the formation of a Canadian Association was read but left over for consideration at the next meeting.

REPORT OF THE SCIENCE SECTION OF THE ONTARIO EDUCATIONAL ASSOCIATION, HELD IN TORONTO MARCH 29-31, 1910.

The Natural Science Section was well attended and good interest was taken. Several excellent papers and addresses were given and some quite helpful and spicy discussions regarding the science curriculum, science collections, notebooks, requirements, and examinations brought out the general opinion that, while collections of plants, woods, insects, etc., and carefully kept notebooks including out-door observations, were excellent, it might be over-emphasized.

The president, L. H. Graham, of Toronto, gave the opening address on "Science as a Culture Study," after which Carl Lehman gave a suggestive paper on the teaching of chemistry, in which he showed that considerable quantitative work could be carried on successfully in elementary class work. R. A. Brunt illustrated by a lantern lecture—in which he used his own slides on various topics—how science teaching and the lantern can be correlated. The relation of nature study to elementary science in the Lomer School was discussed by D. White.

An able lecture by Professor R. Ramsay Wright on "Recent Researches in Heredity," illustrated by numerous charts, showed how, in both plant and animal life, hereditary tendencies are of greater importance even for several generations than most people imagine. A joint meeting with the Mathematical and Physical Section, which Dr. J. C. McLennon illustrated by means of many fine and new experiments, some of the new topics on the curriculum in connection with force, surface tension, radioactivity, etc., was a fitting close to the three days' sessions.

The following officers were elected for the coming year:
Hon. President—Professor R. Ramsay Wright.
President—D. White.
Vice-president—A. P. Gundy.
Secretary-Treasurer—F. J. Johnston.
Councilors—G. S. Johnston, H. B. Fetterley, H. Ayers, W. J. Hamilton, A. Cosens.

SPRING MEETING OF THE NORTHEASTERN OHIO ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The Spring meeting of the Northeastern Ohio Association of Science and Mathematics Teachers was held on Saturday, April 16, 1910, at University School, Cleveland. The following program was presented:

"Some Fool Notions about Geometry and about the Way to Teach It," Professor Frederick Anderegg, Oberlin College.

"Modern Tendencies in School Organization," Principal Wells L. Griswold, Rayen School, Youngstown.

"Some Relations between Science and Agriculture," Director Charles E. Thorne, Experiment Station, Wooster.

About sixty-five members and friends of the Association gathered in the Assembly Room at University School to listen to the papers. After an interesting and spirited discussion of the papers, the meeting adjourned to the Physics Room, where a small but interesting exhibit of apparatus was displayed and some experiments performed.

Mr. A. E. Schade of Medina showed a simple and efficient apparatus for demonstrating the laws of electrical resistance with Wheatstone's Bridge. Professor Geo. H. Colton of Hiram College demonstrated a very peculiar phenomenon of electrostatic attraction and repulsion. A pivoted magnetic needle or other conductor is brought near a charged Leyden jar. The needle is at once attracted, but instead of remaining at some fixed position continues to rotate. No satisfactory explanation of the phenomenon was given. Supt. E. E. Adair of Doylestown displayed a number of pieces in his monthly calendar of homemade apparatus. He brought January (a tangent galvanometer) and February (a primary and secondary coil) with him. As an excuse for not displaying March also, he said that the varnish was not yet dry. He promises a real exhibit of homemade apparatus for the November meeting of the Central Association.

Lunch was served to forty members in Milden Hall—the boarding department of University School—where Mrs. Chandler's hospitality was thoroughly enjoyed.

Director Thorne gave his address immediately after lunch, after which the meeting adjourned.

This is the largest and most enthusiastic meeting of this center of the Central Association. The membership is now larger than at any time in the history of the Association. It is anticipated that the membership will approach 100 by the next meeting. In November the Central Association will be entertained in Cleveland, and all the members in Ohio are looking forward to a large and inspiring meeting. It is expected that several hundred teachers from Ohio alone will attend, besides large numbers from Indiana, Illinois, Pennsylvania, and Michigan, as well as from the other states where the Central Association is represented.

FRANKLIN T. JONES, *Secretary.*

BOOKS RECEIVED.

First Course in Algebra, by Herbert E. Hawkes, Yale University, William A. Luby and Frank C. Touton, Central High School, Kansas City, Mo. 12mo., cloth. vii+334 pages. List price, $1.00. Ginn & Company, Boston and Chicago.

Physical and Commercial Geography, by Herbert E. Gregory, Albert G. Keller and Avard L. Bishop, Yale University. 8vo, cloth, viii+469 pages, 16¼x23¾ cm. Maps. List price, $3.00. Ginn & Company, Boston and Chicago.

The Body and Its Defenses, by Frances Gulick Jewett. 12mo, cloth. viii+342 pages. 16x20 cm. Illustrated. List price, 65 cents. Ginn & Company, Boston and Chicago.

The Care of Trees in Lawn, Street and Park, with a list of trees and shrubs for decorative use. By Bernhard E. Fernow. 1910. Pp. 392. Henry Holt & Co., New York. Price, $2.00 net.

BOOK REVIEWS.

Div-a-let, or Division by Letters, by W. H. Vail, M.D., Newark, N. J. A pamphlet of 70 pages. Second edition. 1910.

This pastime or mental diversion is offered to those who are naturally inclined to mathematical problems. Examples in long division have been worked out, and then letters substituted for the figures. The problem is to find the word of ten letters hidden in the example. Thus, to form puzzle No. 1, 726095384 was divided by 341 and letters of the word *discourage* were substituted for the figures, $d = 1$, $i = 2$, $s = 3$, and so on. To find the word, one must search for hints in the division. There is a fascination in the problems that rivals the interest in the 13-15-14 puzzle. This collection of 323 problems will be sent to any address by the author on receipt of twenty-five cents. H. E. C.

Elementary Course in Perspective, by Sherman M. Turrill, C.E. x+71 pages, 16 illustrations and folding plates. 13×19 cm. Cloth, $1.25 net. D. Van Nostrand Company, New York.

The author of this text is to be congratulated in bringing out a book which makes use of the principles of descriptive geometry in such a clear manner that anyone with a fair understanding of this subject may, without any other assistance, become familiar with the art of perspective drawing. The matter is treated from two points of view: first, the "Method by the Use of the Plan," where the orthographic projection of rays are used, second, the "Method by Scale." The first method is largely for mechanical draftsmen, while the second is intended for the artist and freehand worker. Each of the two parts of the work is divided into five chapters. In each part, parallel and angular perspective as well as the perspective of curves and shadows are discussed according to their particular method. A large number of problems covering the principles involved are given. The drawings of the plates are splendidly executed. The type is large and clear, the matter being well arranged. C. H. S.

Teachers desiring a copy of the recent Monograph by Professor David Eugene Smith, on "The History of the Decimal Fraction," may secure the same by writing to the secretary of Teachers College, Columbia University, New York City.

The Manual Arts for Elementary Schools, Drawing, Design, Construction, by C. S. and A. C. Hammock. First to eighth grade inclusive. Paper. 272 pages. D. C. Heath & Co., Boston and Chicago.

This manual is planned to cover the work in drawing in all grades below the high school. There has been a wise selection of designs for the pupil to copy which when supplemented with the help of the teacher will afford the young pupils a course in drawing as near ideal as is possible to devise. The authors have prepared this manual "believing that the highest development of a program of study and practice for public schools demands the unification of drawing and manual training. This series of books is planned to help in making art in schools more practical and manual training more artistic."

The first three books, 15x20 cm. in size, contain sixteen designs each, without descriptive matter, chosen to please and attract the pupil. Numbers five to eight inclusive are 20x27 cm. in size and contain considerable descriptive matter. The designs treat of all phases of drawing and construction which the average pupil in these grades can easily comprehend. The book should and will have a large sale. C. H. S.

St. Louis Laboratory Manual of Physics, by the physics instructors of the St. Louis High Schools. 7x8½ inches.

This manual is the result of several years' experimentation on the part of the St. Louis instructors and contains only those exercises which gave the best results and which in their judgment brought out the best work from the pupils. It is a loose leaf book containing 76 exercises. The exercises are splendidly arranged, clear and concise, the sheets being printed only on one side. It is divided into three parts corresponding to three terms. Part I contains 26 experiments with 5 on general properties of matter, 7 on mechanics of fluids, 8 on mechanics of solids and 6 on heat. Part II contains 26 experiments with 5 on sound, 9 on light and 12 on magnetism and electricity. Part III contains 24 experiments with 2 on mechanics of fluids, 2 on mechanics of solids, 7 on heat, 7 on electricity, 3 on light and 3 on sound.

While the experiments in Parts I and II cover the ground usually required in a secondary school course, Part III contains those exercises which are more difficult and are probably used for an advanced secondary course. Pupils ought to do good laboratory work with this manual. C. H. S.

The Teaching of Arithmetic, by David Eugene Smith, Professor of Mathematics in Teachers College, Columbia University. 75 cents. Pp. 120. 1909. Bureau of Publications, Teachers College, Columbia University.

Teachers of arithmetic will find this book both interesting and helpful. Two reasons for teaching arithmetic are given: (1) It is useful in a business way to everyone. (2) It gives a kind of training that other subjects do not give. The discussion of these reasons leads to the consideration of what arithmetic should include, and the nature of the problems. The author thinks that our American arithmetics may well lay claim to being among the most progressive that are appearing in this generation.

In chapters VII and VIII the claims of mental and written arithmetic are considered; and many excellent hints are given to the teacher. Chapters XII to XV deal with certain great principles of teaching arithmetic, and subjects for experiment. In the last eight chapters the work of each school year from the first to the eighth is discussed in some detail. The teacher who makes use of these suggestions regarding methods and problems will undoubtedly find that he has increased his efficiency.

H. E. C.

Agriculture and Its Educational Needs, by Andrew S. Draper, Commissioner of Education, State of New York. Cloth, 16mo., 92 pages. 50 cents. C. W. Bardeen, Syracuse, N. Y.

This little book, full of timely information on agriculture, is a revision of the commissioner's address before the State Educational Association at Syracuse, Dec. 29, 1908. It is fortunate for the state of New York, and especially its agricultural interests, that such an earnest advocate of instruction in matters appertaining to rural life is at the head of the schools in that great state. He believes in surrounding the home life of the farmer boy with those advantages which will cause him to desire to remain on the farm rather than be driven away on account of drudgery. He praises highly the work being done at the state agricultural college at Cornell University, discusses that which may be done in the various grades of the elementary schools, and advocates that this work be under state control. This is as it should be, as time, energy and money are conserved by unification of work. He believes in producing better breeds of farm animals and improving the quality of the earth grown products. Above all, the home life of the wives and daughters of the farmers should be made more attractive, with the element of drudgery reduced to a minimum. It is a book which ought to be read by all farmers. C. H. S.

The Gulick Hygiene Series, The Body and Its Defenses, by Frances Gulick Jewett. 12mo cloth, 342 pages. Illustrated. List price, 65 cents. Ginn & Company, Boston and Chicago.

This book is far superior to any of its kind ever published. From cover to cover it is filled with truth and facts with which every person should be familiar. As with all of the books of this series it is written in an interesting and telling manner. "Emphasis is laid on function rather than on structure, on bodily health rather than the mechanical operation of the organs." The reader is impressed with the fact that he alone is largely responsible for his physical condition. That by observing the proper laws of physiology and hygiene he may keep himself in health, prolong his life and at the same time aid humanity in general. Several chapters are devoted to the discussion of communicable diseases and their prevention. Tuberculosis and typhoid fever are studied, what causes them and how they may be avoided. Attention is called to the dangers of the common towel and drinking cup. The dangers from the two pests, the fly and mosquito, are pointed out. A bibliographical list is given as well as 23 pages of questions. A glossary of terms used is appended. A complete index is also found. Typographically and mechanically the book is perfect. It ought to be in the hands of every boy and girl in the land. C. H. S.

A Class Book of Physics, by R. A. Gregory, Queen's College, London, and H. E. Hadley, Principal of the School of Science, Kidderminster. xi +487 pages, 335 drawings and illustrations. $1.10, net. Macmillan Company, New York and London.

This is a very good book for secondary school work. It contains, however, nothing that is essentially new. The manner of treatment of different topics is clear and concise and can be easily understood by the average high school pupil. There are 335 drawings and illustrations, many of which will be new to American readers. They are, on the whole, well selected and to the point. The text is saturated with about 650 well-selected questions and problems covering all phases of the subjects treated.

The book consists of eight parts, divided into thirty-eight chapters. Part one, of thirty-four pages, is devoted to measurements; part two, hydrostatics and mechanics; part three, to heat; part four, to light; part five, to sound; part six to magnetism; part seven to static electrification; and

part eight to voltaic electricity. Not very much is said concerning the application of physics to everyday life. The steam engine is not mentioned, while the dynamo is dismissed with less than two pages of treatment. Four pages are given to the answers of problems contained in the text. This is not a good feature. There is a splendid index of names and terms used. Mechanically the book is well made, the type clear and well selected. Paragraphs begin with bold-face type. C. H. S.

Text-book of General Physics in Mechanics and Heat, by J. A. Culler, Miami University. 12mo, ix+311 pages. 16x23 cm. 225 illustrations. Cloth. $1.80. J. B. Lippincott Company, Philadelphia.

Without doubt one is able to give better instruction in any subject if his pupils are privileged to use a text written by himself. This idea was evidently in the mind of the author, causing him to put into print his thoughts and conceptions of the way in which this part of physics should be taught.

The book presents in a splendid manner the author's idea of what a physics text should be. It is written in a clear and understandable style. A knowledge of trigonometry is necessary in the use of the book. There are six chapters, the respective chapters discussing kinematics, dynamics, solids, gases, liquids and heat. The author has used good judgment in the selection of topics treated. The type is clear ten point. The topical paragraphs all begin with heavy bold face type and in the discussion when emphasis is to be laid on particular terms or phrases they are likewise printed in bold face. The mathematics, as is the convention, are all given in italics. There are 263 numbered equations given in the body of the work. In the appendix are given several proofs not brought out in the general discussion. Thirty-four tables of physical consonants are printed, together with tables of natural trigonometrical functions. The index is complete. The book should command a large sale. C. H. S.

Rara Arithmetica, by David Eugene Smith, Teachers College, Columbia University. Edition in one volume, $5.50. Pp. 506. Ginn & Co., Trade Department, 29 Beacon St., Boston, Mass.

This elaborate bibliography of arithmetic consists of a catalogue of arithmetics printed before 1601, with a description of those in the library of George A. Plimpton, New York. This collection of arithmetics is the largest that has ever been brought together, and there are few arithmetics of much importance that are not found, in one edition or another, in it.

For the task of describing these arithmetics of the formative period in the modern history of the subject, and presenting the whole subject in an orderly and scholarly way, Professor Smith is eminently well prepared. For many years he has devoted much time to the historical side of mathematics, and has worked in most of the large libraries of the world. Hence, teachers of elementary and secondary mathematics will find this work of great value as a reference book.

The ordinary history of mathematics gives the facts of the development of the subject, but here one sees the very work of the early mathematicians, and methods and processes in the making. There are more than two hundred and fifty facsimiles of pages of arithmetics in this book, showing the first printed mention of a slate, the first traces of modern long division in manuscript and in print, the first decimal point and the first scientific treatment of decimals, various forms of multiplication and division, and so on.

The publishers have done their work well and the book is a model of mechanical excellence. H. E. C.

Geology of the City of New York, with illustrations and Maps by L. R. Gratacap, American Museum of Natural History. 3rd edition. x+232 pages. Henry Holt & Company, New York.

This volume without doubt is the most comprehensive one on this subject ever published. It is written by one who is eminently qualified to bring out an authoritative work on the geology of this particular locality. This, the third edition, is greatly enlarged over the first two. A chapter has been added on the geology of the Borough of Brooklyn. Splendid opportunities have recently presented themselves to enable the author to continue his investigation of the geology of this region. The excavations for the subways, tunnelings, the engineering enterprises of the New York Central and Pennsylvania railroads, soundings, dredgings, etc., have enabled Mr. Gratacap to study certain phases of the subject in a manner never before possible.

The book is divided into six chapters. The first, covering 25 pages, headed "Introduction," gives an epitomized description of the geology of North America. Chapter two, of 127 pages, on "Manhattan Island," gives a brief topographical outline of this island, followed by descriptions of the forms of rocks here found, together with a discussion of the remarkable folds and plications of the gneissoid rocks. A discussion of the peculiar water-ways about and near the island is likewise given. An interesting account of the minerals found on this island is found at the end of this chapter. Chapter three is devoted to the geology of the "Borough of Brooklyn and Queens," while the "Bronx" is described in chapter four. The "Borough of Richmond" (Staten Island) is geologically described in chapter five, while the "Evidences of Glaciations in and about Greater New York" are given in chapter six. There are 65 illustrations, made very largely from actual photographs. Four descriptive maps are also found.

The book is clearly and splendidly written and is not only valuable to the geographer and geologist, but will be likewise interesting to the layman. It is a book that ought to be in the home of every inhabitant of Greater New York. The type is clear and easy to read. C. H. S.

Soil Fertility and Permanent Agriculture, by Cyril George Hopkins, University of Illinois, Urbana. 8vo. cloth, xxiii+653 pages, 15×21½ cm, illustrated, $2.75. Ginn and Company, publishers, Boston, New York, Chicago, London, Atlanta, Dallas, Columbus, San Francisco.

This book without doubt is the most comprehensive of its kind ever published. It seems almost unnecessary to say anything about the work after the name of the author has been mentioned, as his name is a sufficient guarantee that it is a masterpiece. The book is written primarily for the farmer upon whom rests the responsibility of supplying the country with food stuffs and who must plan for maintaining the fertility of the soil or else allow it to become ruined by lack of proper soil fertilizer. Secondarily it is written for students, teachers, and those interested in general economic problems and conservation of our national resources.

The author says in the introduction: "It is the purpose of the book to teach the science of soil fertility and permanent agriculture, chiefly by reporting facts rather than by offering theories; and anyone of common sense who reads the English language, and who can understand the common school arithmetic, can understand this book *if he will study it.*"

The book is divided into four parts. Part I, of eleven chapters, is devoted to soil, its chemical composition and requirements for proper plant food; Part II, of seven chapters, treats of the systems of permanent agriculture; Part III, of eight chapters, discusses soil investigations by cultural experiments; and Part IV, of fourteen chapters, talks of the

various fertility factors. There is, too, an appendix of fifty-nine pages in which something is said concerning the production of phosphate rock, model fertilizer law, statistics of agriculture products, methods of soil analysis, and composition of some European soils.

One hundred and twenty-one tables are given, in which is found information on various topics such as composition of soils, crop yields, composition of manures, etc. A complete index is also given. The body of the book is printed in clear ten-point type, while body notes and quotations are set in eight point. Mechanically the book is splendidly made and will stand rough usage. It ought to have a large sale among all who are interested in the welfare of our country. C. H. S.

Elementary Geometry, Plane, by John C. Stone, Head of the Department of Mathematics, State Normal School, Montclair, N. J., and James F. Millis, Head of the Department of Mathematics, Francis W. Parker School, Chicago. Pp. viii+252. 1910. Benj. H. Sanborn & Co., Chicago.

Many mathematics teachers are beginning to feel that they would like to get in touch with the concrete studies which mathematics should subserve. They feel the reasonableness of the demand of the times that schools should in as large measure as possible prepare boys and girls for their future vocations, and are ready to adopt new methods and use text-books which give hope of attaining this end. As the average teacher has little time to collect problems and devise experimental work, new books of the type represented by this geometry are very welcome.

The authors have sought to meet the present-day needs of secondary school teachers and pupils in three ways: (1) They have *vitalized* geometry by relating it to the practical uses of real life by means of real problems, (2) the subject-matter has been rearranged so that as far as possible the easiest and most practical parts of the subject come in the first half of the year's work, (3) better methods of presentation have been chosen. The authors may be fairly said to have achieved their purposes, and the book is sure to find favor with many teachers.

It would seem that the applied problems are well within the comprehension of the average pupil. These problems begin early, on page 17, are well distributed through the book, and are direct applications of the theorems which they follow. They touch the vital principles of work in shops, in the field, and in laboratories. To find the angle of elevation of the sun; to lay out patterns for parts of machines; to add forces; to lay off angles, run lines, compute distances and heights, lay out railroad curves, draw to scale; to verify the geometrical construction of arches and windows, construct arches with given span and rise; to make ornamental designs—these, to name only a few of the types of problems, show their diversity.

Formal demonstrations are not given until page 23. One of the most commendable features of the book is the early and continued use of the straight edge, compasses, protractor, and triangle in making constructions and solving problems. There can be no doubt but what this is the most efficient method of beginning the study of geometry. There is great advantage, too, in numbering the steps of a proof, and putting statements in the form of equations. The proof of a large number of theorems are suggested only, and these, with the large number of traditional original exercises, furnish sufficient practice in logical demonstration. The introduction of the trigonometric ratios, the omission of many useless theorems, the brief treatment of the theory of limits, the use of exercises for algebraic solution are all in accord with present-day beliefs. H. E. C.

Broad Lines in Science Teaching, by F. Hodson, Senior Science Master of Bedales School, England. Cloth, pages xxxvi+267, 16×23 cm. Price, $1.25 net. The Macmillan Company, 66 Fifth Avenue, New York City.

This book is a compilation of twenty-one papers, by as many authors, dealing with the teaching of science in secondary schools, especially in England. The authors, with one exception, Dr. C. R. Mann of the University of Chicago, are all school men in England. The ground covered by the book is, therefore, from so many points of view that the reader is given a broad comprehension of the work being done in science in that country. The editor says in the preface, "The various writers have drawn attention to requirements which in the ideal case should be satisfied; correlation between subjects and between stages, claims of rival departments of scientific study, claims of heuristic or other methods of teaching; claims of practical application to health, home, and morals; the bearing of scientific ideas in neighboring branches of learning has also been touched upon."

The subjects of the twenty-one papers are as follows: "The Place of Science in the School Curriculum," "The Scope of Nature Study," "The Teaching of Nature Study," "Biology in Schools," "The Teaching of Hygiene," "The Place of Hypotheses in Science Teaching," "The Claims of 'Research' Work and Examinations," "School Mathematics in Relation to School Science," "Coördination of Physics Teaching in School and College: With Special Reference to Electricity and Magnetism," "Geography," "Science in the Teaching of History," "Economic Science in Secondary Schools," "Domestic Science," "The Teaching of Chemistry in Technical Schools," "How the School May Help Agriculture," "Engineering Science Teaching and the Training of the Affections," "Science Teaching and the Child's Philosophy," "The Present Condition of Physics Teaching in the United States," "School Science in Germany," and "Some Practical Notes on the Planning of Science Laboratories."

It is a very readable and interesting book, one from which a person can quickly acquire a knowledge of the condition of science teaching in England and thus be able to help in applying the good points in teaching the same subjects in his own country. C. H. S.

Physical and Commercial Geography, by H. E. Gregory, A. G. Keller, and A. L. Bishop. 469 pages, 26 figures, and 3 plates. Ginn & Co.

A university text embodying some of the modern ideas of geography, in which the "Science of Environment" is presented in a "medley" of physical geography, anthropology, and industrial history. This is a serious and a successful attempt to interpret the facts of geography rather than list them, the mnemonic method of commercial geography is eliminated, and the results justify the educational value of interpretation.

The subject matter has three distinct parts: the Natural Environment, the Relation of Man to Natural Conditions, and the Geography of Trade.

The physical aspects of man's relation to the earth receive a unique treatment in the chapters devoted to the Natural Environment. The explanation of the various phenomena of physical geography is absent, but there is considerable emphasis upon the relation of the physical features to the activities of man. This is a distinct departure from the current American text-book treatment of physical geography which makes so prominent the physiographic processes or utilizes problems which properly belong to structural work or dynamic geology. The method of this text of approaching the problems in man's relation to the physical features involves excellent disciplinary training fully as valuable as that obtained from physiographic studies.

The chapters on the Relation of Man to Natural Conditions are a vital link between the two phases of geography discussed in this text. The influence of Ratzel dominates in these chapters and there is much material ably presented which serves to verify the geographic principles that are constantly used in the interpretation of life relations.

The final part of the text is devoted to the Geography of Trade, in which the common raw materials are used as the foundation for the discussions of the larger problems of manufacturing and commerce. The entire world is not treated in the usual cyclopedic manner, but rather those countries which dominate the commerce of the globe and have a potent influence upon the United States. The chapter on transportation is a concise summary of the various factors which have been the determining influence upon its development. There is an obvious error in the reference on Page 333 to the size of boats and tonnage on the Great Lakes. The Le Grand S. DeGraff is 605 feet in length. The closing chapter is a miscellaneous collection of data concerning products that might have been omitted or placed in one of the appendices. The book is remarkably clear in its statements and free from errors. It will be a text much used by secondary schools for reference and especially for its presentation of a new phase of geography.

W. M. GREGORY.

Fungous Diseases of Plants, by Duggar, Benjamin Minge. With chapters on Physiology, Culture Methods and Technique. pp. 508. Figures 239. Ginn & Company. 1909.

Students and teachers alike have reason to be grateful to Professor Duggar for the service he has rendered in the publication of his "Fungous Diseases of Plants." Heretofore there has been no comprehensive work available in this field. The literature of the subject is embarrassing in its abundance but only a specialist could be expected to find his way through it. The rest of us have been obliged to rely upon Tebeuf, Goebel and De Bary. These texts could not be satisfactory for American forms are almost wholly morphological, and are now rather out of date. In any case they could not be used for specific determination nor as a source of information on the economic side of the subject.

Professor Duggar describes about a hundred and seventy-five diseases of plants, giving in each case the symptoms of the disease, the morphology of the casual fungus, and methods of control. The characterization of the symptoms of the disease is untechnical, concise and sufficient for diagnosis, even by the layman, with a high degree of probability. The description of the fungus is clear and detailed, and includes all characters likely to be of interest as well as those of especial taxonomic value. The method of control are presented in a manner that loses nothing of scientific accuracy by being within the grasp of the average unscientific plant grower. The very clear presentation of all phases of the subject will be especially gratifying to all teachers who refer to the book.

The author, besides presenting a valuable manual, has set a model for the proper relation of technical and economic matter in science text-books. Economic facts and bearings are presented without sacrificing the scientific viewpoint in the least; the language is untechnical without becoming unscientific, but approved terminology is used wherever the subject demands it; and both phases of the subject are so intimately related on every page that one cannot conceive how the book could have been written otherwise. This recognition of the close relation existing between "practical science" and "pure science" with the dominance of neither, seems to mark a distinct forward step in the making of text-books. It is to be hoped that later authors will follow this excellent example.

This work will doubtless be used as a text-book in those schools which offer courses in this rather special branch of botany but its wider sphere of influence will be found as a book of reference. That it must be on the shelves of every earnest teacher and student of botany is evident. The specialists in the fungi will have it at hand, and to the progressive agriculturist it will be invaluable.

The chapters on technique and on physiological relations are likely to be of great value to teachers, especially to those who have had only a very general training in this group.

Excellent general and host indexes add to its usefulness. The method of citing important papers in the heading of each section facilitates reference to original authorities. W. L. EIKENBERRY.

Plane Geometry with Problems and Applications, by H. E. Slaught of the University of Chicago and N. J. Lennes of the Massachusetts Institute of Technology. 275 pages, showing practical applications of Geometry. Allyn and Bacon, Boston. 1910.

In the Plane Geometry, by Slaught and Lennes, the authors have shown themselves to be in accord with the views of the more progressive mathematicians and educators of the present day who hold that all subject-matter for educational purposes should be modernized and made practical and selective.

The authors have modernized plane geometry by breaking away from the old stereotyped forms in which axioms, definitions and principles have persisted since the days of Euclid. The number of assumptions has been greatly increased and their scope has been very much broadened. Many of the old theorems which are so easy to see, yet so difficult of rigorous proof, and which so often bring from the beginner the exclamation, "Why, anyone can see that; what is the use of proving it?" have either been accepted as self-evident or else they have been approached from a new point of view. The subject-matter is practical in many ways. The general statements of theorems are followed by specific problems which involve their application and which are taken from the common experiences of boys and girls. Things about which the students may know without technical study are used in this connection and treated in the same way in which the man of affairs treats them. The problems which have been drawn from architecture, design, decoration, and the easier points of the trades are much more practical and helpful and not less scientific than the ordinary abstract exercises which have been copied and multiplied ever since the ancient mathematicians proposed them as a means of recreation for those who had nothing else to do.

In this book, geometrical figures are brought before the student as they exist in tracery windows, linoleum designs, ceiling patterns, and so on. Problems involving difficult technicalities and mystifying conditions have been avoided. Those have been used which involve the geometrical truth but which do not surround it with so much else which needs explanation that the pupil fails to reach its significance. No attempt is made to multiply theorems and propositions. Those which are essential to a logical treatment of the subject are presented. It seems best to furnish pupils with those geometric tools which are of general use and disregard those which they will scarcely learn to manipulate.

The individuals for whom the subject-matter is intended have been taken into account. Highly theoretical material, such as theory of limits and incommensurables, has been omitted or reserved for a closing chapter which may be given in a review course, or to those classes which show more than ordinary strength. These omissions have left room which the authors have

used to vitalize the work for the boy or girl by inserting many of the concrete problems and applications mentioned above as falling very generally within the experience of the high school student.

Correlation has been provided in two ways. First, geometry is correlated with algebra by having algebraic problems which are interpreted geometrically and also by suggesting geometric problems for algebraic interpretations. The use of the graph in geometry is shown to be of value just as it is in algebra. Secondly, geometry is correlated with trigonometry, in that some of the practical problems, leading up to the necessity for the theorem that two sides of a triangle are proportional to the sines of the opposite angles, are suggested for investigation. Not only is geometry correlated with algebra and trigonometry; but what is more important the material in geometry itself is thoroughly correlated by means of problems, exercises and summaries.

The text seems to be organized with another important point in view. The authors evidently realize that a student, to become proficient in geometry, must develop a geometric attitude and method of attack. Valuable hints are given on the nature of a demonstration, methods of attacking a problem and plans of procedure. In some cases demonstrations are given in full throughout the text, but, as a rule, the outlines of proofs only are suggested or the analytic method is used to lead the pupil to see for himself what is needed in a proof and in what order to proceed. The book is written on the "suggestive" plan but this plan is not carried to excess. Great skill is used in both the demonstrations and the exercises in selecting thought provoking questions which neither make things too easy nor too difficult for the pupil.

Throughout the book the theory and definitions come as the result of logical development. Both are so adjusted that the proofs given are clear, concise, and rigorous. The presentation is thorough and the summaries at the ends of the chapters will cause the student to review and reorganize the subject-matter for himself.

W. P. MORGAN.

Englewood High School, Chicago.

GRAPHIC RAILROAD TIME TABLE REFERENCES.

Apropos of Professor Cajori's article on Graphic Railroad Timetables in the March number of SCHOOL SCIENCE AND MATHEMATICS I might add that references to the same subject can be found in:

Borel, "Algèbre," Second Cycle, Paris, 1903;
Bourlet, "Précis d'algèbre," 4th edition, Paris, 1907;
Tannery, "Notions de Mathématique," Paris, 1903;
Laisant, "Initiation Mathématique," Paris, 1906;

and doubtless in other French elementary text-books.

W. W. BEMAN.

Wood pipe has been used for centuries as a means for conveying water. The first water supply of London had a distributing system made from wooden pipe. The city of Philadelphia built a public water works in 1799 and not only used wooden water mains but also wood fire hydrants. The wood pipes consisted of spruce and pine logs bored out, mortised and tenoned at the ends, with wrought iron bands fastened around each end. Many of these pipes were in continuous use until 1844.

SCIENCE AND MATHEMATICS SOCIETIES.

Under this heading are published in the February, June and October issues of this journal the name and officers of such societies as furnish us this information. We ask members to keep us informed as to any change in the officiary of their society.

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